CSDL Informal Technical Note No. 12

NOS HISTORICAL CIRCULATION SURVEY DATA RESTORATION: PUGET SOUND (1976-1978), YAQUINA RIVER (1982), WILLAPA BAY/GRAYS HARBOR (1982), AND COOS BAY (1982)

Silver Spring, Maryland
May 2012

noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Coast Survey Development Laboratory

Office of Coast Survey
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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ABSTRACT

The purpose of this report is to document the restoration of the National Ocean Service (NOS) historical circulation survey data in Puget Sound (1976-1978), Yaquina River (1982), Willapa Bay/Grays Harbor (1982), and Coos Bay (1982). Previous computer programs developed for Delaware River and Bay circulation survey data (2006) were used to analyze conductivity-temperature and current (CT/Current) data (Richardson and Schmalz, 2006). There were no conductivity-temperature depth (CTD) profile data available. Based on plots of salinity, temperature, current speed and direction at CT/Current moorings, temperature, salinity and current speed and direction data quality was assessed and indicated in the dataset tables. Meteorological data (sea level atmospheric pressure, air temperature, and wind speed and direction) were either not collected or not considered due to data issues. This report is meant to serve as a supplement to the Puget Sound circulation survey report and to serve as the circulation survey report for Yaquina River, Willapa Bay/Grays Harbor, and Coos Bay.

While no formal quality control has been performed, the data processing algorithms, which may be used to accomplish this are described. Investigators may use these or other approaches for further quality control. Each estuary is next presented in a separate chapter, including a description of data inventories of both raw and processed data files. Discussion of the CT/current data is followed by regional oceanographic considerations. Major data preservation and data use issues are then addressed. In conclusion, an overall summary is provided along with recommendations for additional data analysis tasks.

1. INTRODUCTION

From 1976 through 1982, the National Ocean Service (NOS) conducted circulation surveys in Puget Sound (Parker and Bruce, 1980), Yaquina River, Willapa Bay/Grays Harbor, and Coos Bay. Due to corruption in computer system transfer and lost media, these datasets have been lost. To restore the available datasets, the remaining conductivity-temperature and current (CT/Current) data collected during these surveys were obtained from the Center for Operational Oceanographic Products and Services (CO-OPS) and analyzed.

While no formal quality control of the data was performed, this report does review the data quality control and analysis programs previously used by Loeper (2006) and Richardson and Schmalz (2006) in Chapter 2. In Chapters 3-6, Puget Sound, Yaquina River, Willapa Bay/Grays Harbor, and Coos Bay circulation survey data processing and analysis are considered, respectively. In each chapter, raw and processed data inventories of CT and current data are presented. Time series of salinity, water temperature, current speed and direction data at CT/Current moorings at representative estuarine stations are plotted. Water temperature, salinity, and current speed and direction spikes were minimal and were not edited out of the record. Some further filtering and editing may be required prior to model-data comparison. CTD vertical profiles and meteorological data were either not collected or not available. In Chapter 7, data preservation and data use issues are considered. In Chapter 8, conclusions and recommendations for future work are advanced.

2. DATA PROCESSING ALGORITHMS

An initial quality control of the current and CT data can be performed using the program currnt.f developed during the Delaware Bay circulation survey data restoration (Richardson and Schmalz, 2006). This program can be used to initially plot salinity, temperature, current speed, and current direction data. After these plots have been reviewed, one can determine which data sets require removal of bad data segments. This first step was performed during this study to analyze the datasets and inventory bad data as given in the station inventory tables. Subsequent steps which can be employed are as follows: 1) clipping of current direction data to remove spikes, 2) application of a box-car type filter to remove spikes in salinity, temperature, current speed and direction data. The use of the program is outlined in the following paragraphs.

The first variable read from the control file is initplot. With initplot set to 1, the program will plot the unfiltered, unedited data. For any changes, brought about either through filtering or through editing, to be observed in the plots, initplot must be set to 0. With initplot equal to 0, the program will automatically eliminate (filter) spikes in salinity, temperature, and current speed data using a box car type filter. However, the program will not automatically handle bad portions (multiple spikes or noise) of salinity, temperature, and current speed data. When multiple spikes occur, the nedit option must be used.

The nedit portion of the program substitutes a null value for bad data. Bad data segments are considered to be those in which there is clear evidence of instrument malfunction. With nedit equal to 0, no editing will occur. If there are n segments of data requiring editing, then nedit will be set to n. The parameters which are required in the control file for a segment of data to be edited include: the station name, the depth of the reading, and the year in which the data was recorded. Also required are the start and stop dates for the bad data segment, and the integer indicator for each data type. If the salinity data are good, iedt_s is set to 0. If the salinity data requires editing, iedt_s is set to 1. The indicator for temperature data is iedt_t and the indicator for current data is iedt_cur.

During this study, only those data segments of 15 days or longer are plotted with information printed to output file time.out2. The information printed to time.out2 is particularly useful when editing data plots. This information includes the station number, the depth of the reading, the year of the reading, and the start and stop dates (Julian days) for the data segment. Also printed to time.out2 is the plot number. The plot number is particularly useful when using display to observe the plots, and from there, to edit data. No editing of data was performed during this study.

A new version of Program currnt.f was developed to write the station files for each dataset in NOS skill assessment format as described by Zhang et al. (2009) for Puget Sound, since this area will be included in the NOS operational nowcast/forecast system suite in 2013.

Due to lack of data availability, no CTD data were analyzed and the program sets previously described by Loeper (2006) and Richardson and Schmalz (2006) were not used.

3. PUGET SOUND

NOS performed an intensive 3-year survey from 1976 through 1978 to study the circulation in Puget Sound. The study was performed during the late Spring and Fall months to avoid ice. Over the study period, 135 current meter locations and over 322 locations of conductivity and temperature versus depth (CTD) were occupied (Parker and Bruce, 1980). The Aanderaa Model RCM-4 current meter recorded and measured current speed and direction and included temperature and conductivity and pressure sensors. Here, we summarize the recovered data and discuss related regional oceanographic characteristics.

Data Inventory and Summary

The datasets available from CO-OPS on compact disc are listed in Table 3.1 and constitute the recoverable data. It was necessary to carefully inventory these datasets and determine their data quality. Note that no meteorological data (wind speed and direction, and sea level atmospheric pressure) were collected (Parker and Bruce, 1980). The over 322 CTD profile data were lost. It should be noted that Parker and Bruce (1980) document the Puget Sound Approaches circulation survey which occurred in 7 phases. Phase 1 occurred during the Fall of 1973 and was the preliminary planning phase. The next six phases occurred during the Spring and Fall of years 1974-1976. The project was termed OPR-509 and was extended to include the waters of Puget Sound in phases 7 -9 occurring during Spring and Fall 1977 and Spring 1978 as well as the western half of the Strait of Juan de Fuca in the Fall of 1978.

Table 3.1. Puget Sound Circulation Survey Raw Data Inventory.

Directory Name	Number of Files	Data Period	Data Description	Data Quality
PUGET1	257	1976-77	Aanderaa Current Meter	OK

In Table 3.2, the raw, edited, and final quality controlled datasets are given along with their location on the CSDL/MMAP SAN. The general processing approach was to keep the same file structures as the original datasets. Each dataset was plotted and then written to output files in exactly the same format as the original data. It should be noted that since the focus was on data for model validation and harmonic analysis, only stations with record lengths of 15 days or greater were considered. In general, data quality was high and no editing was performed. However, some of the station time series exhibited high frequency spikes, which may need to be further filtered and edited prior to model-data comparison. Parker (1977) presented the results of Project OPR-508 phases 1-7 in terms of an analysis of the tidal hydrodynamics via harmonic analysis of water levels and currents.

CT/Current Data

The salinity and temperature and current data were distributed amongst four directories: Puget1, Puget2, Puget3, and Puget4. The data files in these directories (FILE1 through FILEn) were concatenated to create cumulative data files; e.g., file_puget1, file_puget2, file_puget3, file_puget4. The data in each individual data file (FILE1 through FILEn) represent current and CT data at one specific station location, over a given time period.

The four datasets are inventoried in Table 3.3 through Table 3.6, respectively, in terms of station location, measurement and station depths and measurement dates and durations. It should be noted that since limited station depths are available in datasets 2 through 4, it was necessary to estimate these depths using Nautical Chart 18440 30th Edition and Nautical Chart 18400 48th Edition. Station locations for C-139 in dataset 2 and C-173 in dataset 4 are questionable. Stations locations are shown in Figures 3.1 through Figures 3.5, respectively, for each of the four datasets. These tables and figures serve as a supplement to the Puget Sound Circulation Survey Report (Parker and Bruce, 1980).

Table 3.2. Puget Sound Circulation Survey Processed Data File Inventory

Data Type	Location	Filename
CT/Current Raw	~/PUGET1/	FILE1 – FILE257
CT/Current	~/puget1/, ~/puget2/, ~/puget3/, ~/puget4/,	file_puget1.ed, file_puget2.ed, file_puget3.ed, file_puget4.ed
CT/Current Qc	~/qc/	file_puget1.qc, file_puget2.qc, file_puget3.qc, file_puget4.qc

~ = /disks/NASUSER/philr/westcoast

Table 3.3. Puget Sound Dataset 1.

Station No.	Latitude (°N)	Longitude (°W)	M-Depth (ft)	S-Depth (ft)	Measurement Dates mm/dd/yr		Data Length Days	Data Quality S TAD
C-62	48.464	123.117	-15	199.340	9/ 2/76	9/17/76	15.01	x
C-62	48.464	123.117	-70	199.340	9/ 2/76	9/17/76	15.01	x
C-104	48.508	123.207	-40	192.940	9/ 2/76	9/20/76	17.83	x
C-104	48.508	123.207	-70	192.940	9/ 2/76	9/20/76	17.83	x
C-105	48.498	123.274	-15	65.230	9/ 3/76	9/20/76	17.11	x
C-105	48.498	123.274	-70	65.230	9/ 3/76	9/20/76	17.12	x
C-105	48.498	123.274	50	65.230	9/ 3/76	9/20/76	17.12	x
C-101	48.511	123.181	-40	251.460	9/ 3/76	9/20/76	16.94	x
C-122	48.613	123.332	-15	37.190	9/ 3/76	9/22/76	19.06	
C-122	48.613	123.332	50	37.190	9/ 3/76	9/22/76	19.06	x
C-63	48.451	123.161	-13	199.340	9/16/76	10/ 6/76	19.80	
C-63	48.451	123.161	-68	199.340	9/16/76	10/ 6/76	19.79	x
C-63	48.451	123.161	50	199.340	9/16/76	10/ 6/76	19.81	
C-102	48.586	123.221	-42	264.870	9/21/76	10/ 7/76	16.00	x
C-102	48.586	123.221	-72	264.870	9/21/76	10/ 7/76	16.12	
C-103	48.592	123.252	-20	57.000	9/21/76	10/ 6/76	15.00	x
C-103	48.592	123.252	-75	57.000	9/21/76	10/ 6/76	15.00	x
C-107	48.648	123.250	-70	160.020	9/21/76	10/ 6/76	15.01	
C-109	48.701	123.317	-71	58.830	9/21/76	10/ 6/76	15.03	x
C-109	48.701	123.317	50	58.830	9/21/76	10/ 6/76	15.03	x
C-106	48.649	123.143	-70	99.060	9/22/76	10/ 7/76	15.00	x
C-113	48.682	123.143	-15	84.430	10/ 5/76	10/20/76	15.01	x
C-113	48.682	123.143	-70	84.430	10/ 5/76	10/20/76	15.01	x
C-113	48.682	123.143	50	84.430	10/ 5/76	10/20/76	15.02	x
C-121	48.739	123.294	-72	140.510	10/ 5/76	10/20/76	15.00	x
C-121	48.739	123.294	50	140.510	10/ 5/76	10/20/76	15.00	
C-110	48.709	123.283	50	73.770	10/ 7/76	10/22/76	15.02	x
C-138	47.947	122.580	-14	0.000	2/16/77	3/ 3/77	15.03	x
C-138	47.947	122.580	69	0.000	2/16/77	3/ 3/77	15.04	x

Notes: M-Depth=measurement depth, where positive numbers are distance above the bottom and negative numbers are distance below the surface. S-Depth=station depth. Note x denotes bad data within the STAD station matrix where S=salinity, T=temperature, A=current speed, and D=current direction.

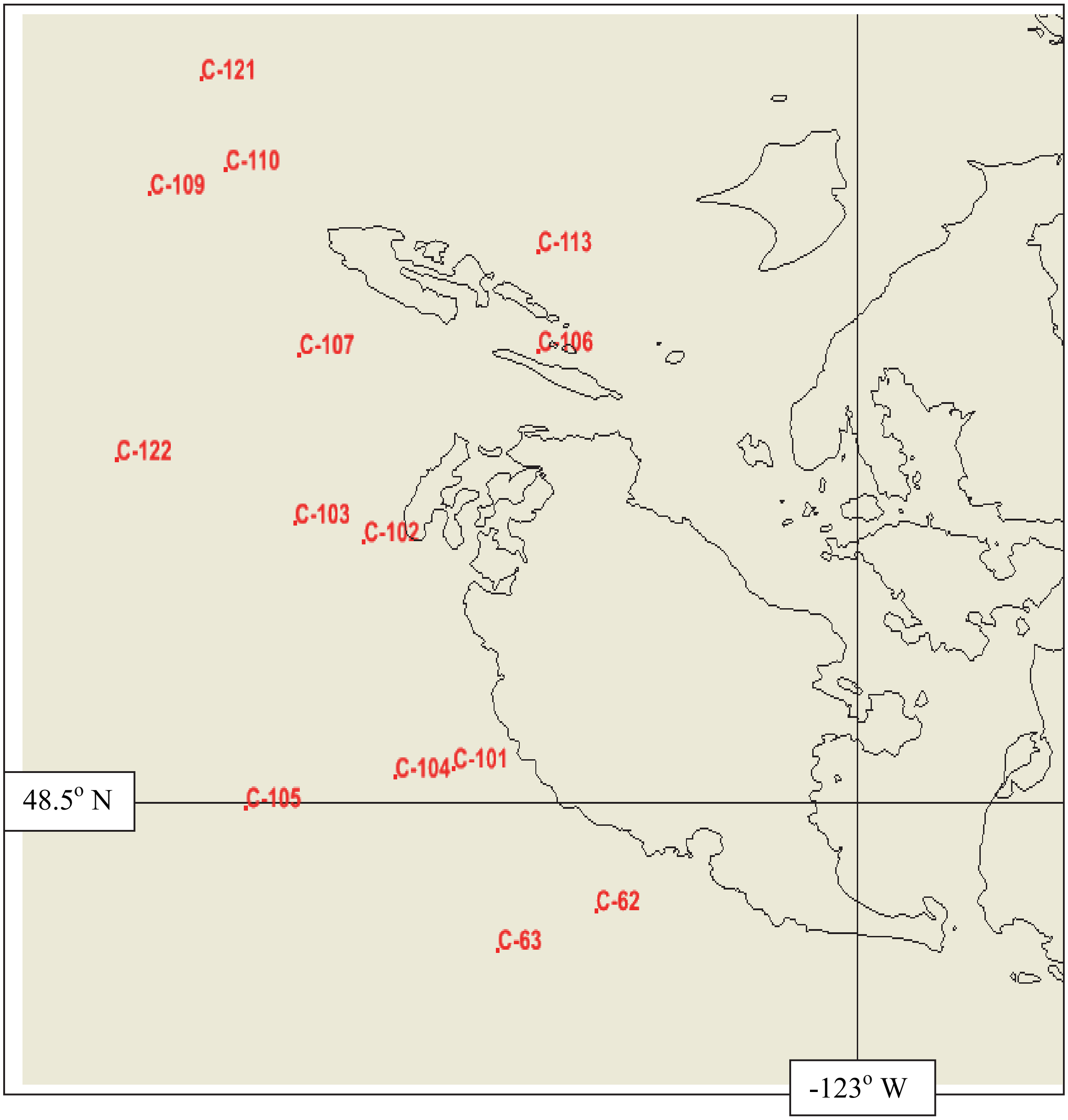


Figure 3.1. Station Locations for Puget Sound Dataset 1.

Table 3.4. Puget Sound Dataset 2.

Station No.	Latitude (°N)	Longitude (°W)	M-Depth (ft)	S-Depth (fathoms)	Measurement Dates mm/dd/yr		Data Length Days	Data Quality STAD
C-139	47.959	122.408	50	n/a	2/16/77	3/18/77	30.05	x
C-136	47.928	122.633	50	55	2/16/77	3/21/77	32.90	x
C-149	48.081	122.435	50	59	2/17/77	3/22/77	33.08	x
C-136	47.928	122.633	-17	55	2/28/77	3/21/77	20.94	x
C-136	47.928	122.633	-72	55	2/28/77	3/21/77	20.97	x
C-139	47.959	122.408	-16	n/a	3/ 1/77	3/18/77	17.03	x
C-139	47.959	122.408	-71	n/a	3/ 1/77	3/18/77	17.04	x
C-147	48.014	122.351	-15	89	3/ 2/77	3/23/77	21.11	x
C-147	48.014	122.351	-70	89	3/ 2/77	3/23/77	21.11	xx
C-147	48.014	122.351	50	89	3/ 2/77	3/23/77	21.11	xx
C-150	48.170	122.556	-16	42	3/ 2/77	3/22/77	20.15	x
C-150	48.170	122.556	-71	42	3/ 2/77	3/22/77	20.16	x
C-140	47.963	122.559	-20	33	3/ 2/77	3/18/77	15.80	x
C-140	47.963	122.559	-75	33	3/ 2/77	3/18/77	15.81	x
C-140	47.963	122.559	50	33	3/ 2/77	3/18/77	15.83	x
C-149	48.081	122.435	-15	59	3/ 3/77	3/22/77	19.22	x
C-149	48.081	122.435	-70	59	3/ 3/77	3/22/77	19.23	x
C-137	47.896	122.603	-15	50	3/14/77	3/31/77	16.82	x
C-137	47.896	122.603	-70	50	3/14/77	3/31/77	16.82	x
C-143	47.921	122.455	-14	40	3/15/77	3/31/77	16.03	x
C-137	47.896	122.601	50	50	3/14/77	4/14/77	30.83	
C-132	48.027	122.634	-15	61	3/15/77	4/ 6/77	22.83	
C-132	48.027	122.634	-70	61	3/15/77	4/ 6/77	22.77	x
C-132	48.027	122.634	50	61	3/15/77	4/11/77	27.82	
C-143	47.921	122.455	50	40	3/15/77	4/14/77	29.96	x
C-144	47.910	122.349	50	100	3/15/77	4/14/77	29.99	
C-145	47.953	122.333	50	99	3/16/77	4/15/77	30.00	x
C-141	47.913	122.512	55	44	3/22/77	4/14/77	23.02	
C-148	48.083	122.338	-15	55	3/23/77	4/ 7/77	15.06	x
C-148	48.083	122.338	-70	55	3/23/77	4/ 7/77	15.08	x
C-148	48.083	122.338	50	55	3/23/77	4/ 7/77	15.07	x
C-147	48.015	122.350	-19	89	3/29/77	4/20/77	21.79	x
C-147	48.015	122.350	50	89	3/29/77	4/20/77	21.76	x
C-144	47.910	122.349	-16	100	3/30/77	4/14/77	15.17	x
C-144	47.910	122.349	-71	100	3/30/77	4/14/77	15.21	x

Notes: M-Depth=measurement depth with respect to MLLW, where positive numbers are distance above the bottom and negative numbers are distance below the surface. S-Depth=station depth with respect to MLLW. Note x denotes bad data within the STAD station matrix where S=salinity, T=temperature, A=current speed, and D=current direction.

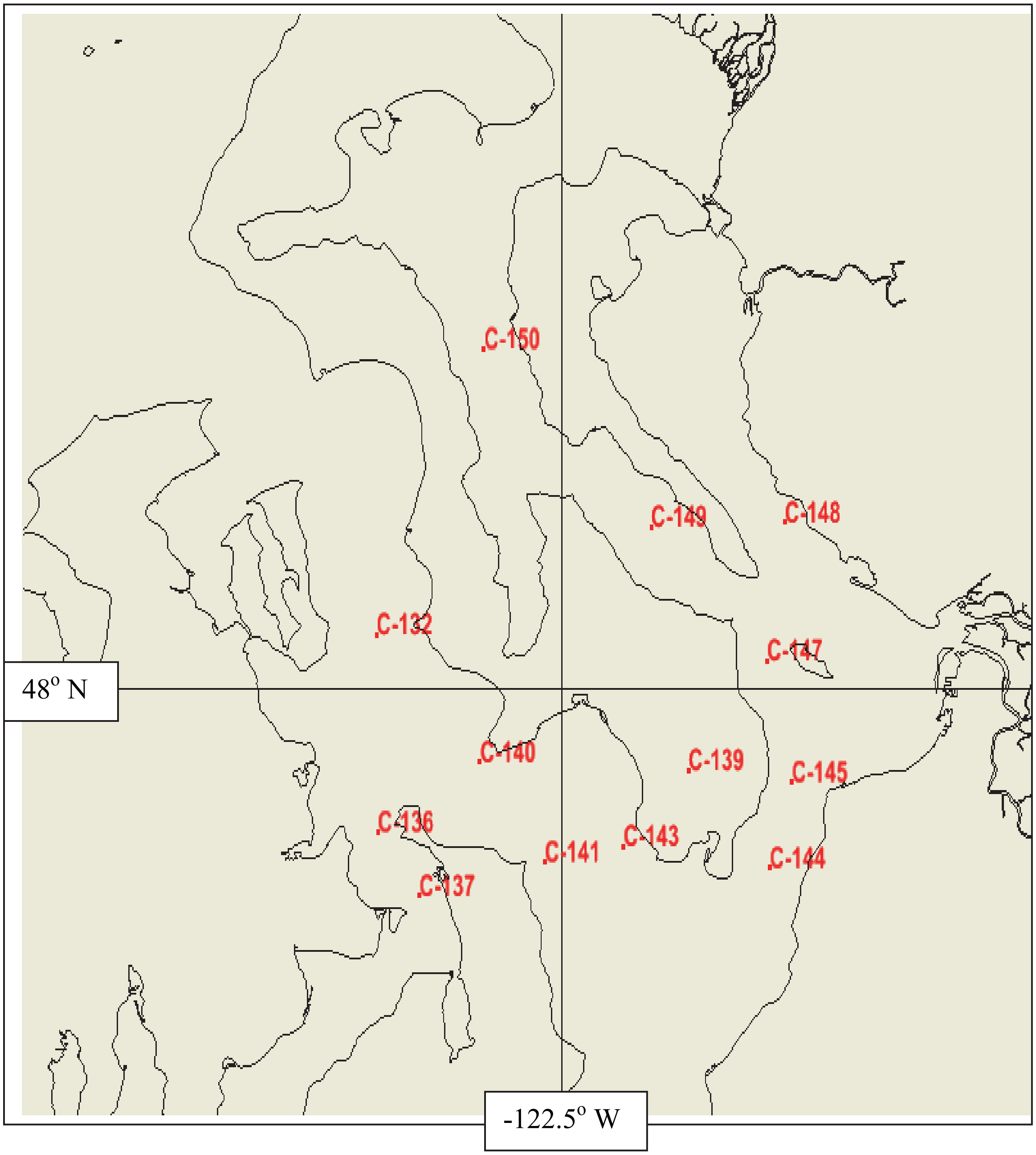


Figure 3.2. Station Locations for Puget Sound Dataset 2.

Table 3.5. Puget Sound Dataset 3.

Station No.	Latitude (°N)	Longitude (°W)	M-Depth (ft)	S-Depth (fathoms)	Measurement Dates mm/dd/yr		Data Length Days	Data Quality STAD
C-145	47.953	122.333	-14	99	3/30/77	4/15/77	15.23	x
C-145	47.953	122.333	-69	99	3/30/77	4/15/77	15.24	x
C-143	47.918	122.453	-27	40	9/ 8/77	9/26/77	18.03	x
C-143	47.918	122.453	-82	40	9/ 8/77	9/26/77	18.01	x
C-144	47.907	122.354	-16	100	9/ 8/77	9/26/77	18.05	x
C-144	47.907	122.354	-71	100	9/ 8/77	9/26/77	18.06	x
C-151	47.878	122.412	-20	9	9/ 8/77	9/26/77	17.97	x
C-155	47.572	122.531	-22	10	9/12/77	9/28/77	15.88	x
C-152	47.807	122.446	-70	95	9/ 9/77	9/27/77	18.01	
C-154	47.701	122.442	-49	112	9/ 9/77	9/27/77	18.01	x
C-143	47.918	122.453	50	40	9/ 8/77	10/11/77	33.03	xx
C-144	47.907	122.354	50	100	9/ 8/77	10/11/77	33.05	x
C-152	47.808	122.449	50	95	9/ 9/77	10/13/77	34.02	
C-154	47.701	122.442	-300	112	9/ 9/77	10/12/77	32.95	
C-154	47.701	122.442	16	112	9/ 9/77	10/12/77	32.95	x
C-156	47.582	122.448	-12	120	9/12/77	10/12/77	30.05	x
C-156	47.582	122.448	-67	120	9/12/77	10/12/77	30.05	xx
C-156	47.582	122.448	50	120	9/12/77	10/12/77	30.06	x
C-161	47.390	122.357	-15	105	9/12/77	9/28/77	15.99	x
C-161	47.390	122.357	-70	105	9/12/77	9/28/77	15.99	x
C-151	47.878	122.412	16	9	9/27/77	10/12/77	15.11	
C-152	47.808	122.449	-21	95	9/27/77	10/13/77	15.97	x
C-162	47.720	122.556	-16	6	10/11/77	10/27/77	15.75	x x
C-154	47.706	122.443	-301	112	10/12/77	11/ 9/77	28.15	xx
C-154	47.706	122.443	16	112	10/12/77	11/ 9/77	28.16	xx
C-166	47.650	122.462	-12	125	10/13/77	10/28/77	15.01	
C-164	47.354	122.539	-14	50	10/17/77	11/ 2/77	16.12	x
C-164	47.354	122.539	-69	50	10/17/77	11/ 2/77	16.13	x
C-163	47.322	122.521	-15	50	10/17/77	11/ 1/77	15.06	
C-163	47.322	122.521	-70	50	10/17/77	11/ 1/77	15.08	
C-159	47.502	122.438	-19	94	10/18/77	11/ 2/77	15.08	xx
C-159	47.502	122.438	-74	94	10/18/77	11/ 2/77	15.08	x xx
C-159	47.502	122.438	50	94	10/18/77	11/ 2/77	15.09	
C-160	47.507	122.405	-16	75	10/18/77	11/ 2/77	15.06	
C-160	47.507	122.405	-74	75	10/18/77	11/ 2/77	15.06	
C-164	47.354	122.539	50	50	10/17/77	11/ 2/77	16.05	x
C-167	47.454	122.405	50	122	10/13/77	11/16/77	34.05	xx
C-163	47.322	122.521	50	50	10/ 7/77	11/ 7/77	30.19	x
C-165	47.308	122.557	50	30	10/18/77	11/18/77	30.16	
C-160	47.507	122.405	50	75	10/18/77	11/17/77	30.01	
C-166	47.650	122.462	-12	125	10/28/77	11/16/77	19.00	x
C-166	47.650	122.462	-67	125	10/28/77	11/16/77	19.01	x
C-167	47.454	122.405	-15	122	10/28/77	11/16/77	19.14	

Notes: M-Depth=measurement depth with respect to MLLW, where positive numbers are distance above the bottom and negative numbers are distance below the surface. S-Depth=station depth with respect to MLLW. Note x denotes bad data within the STAD station matrix where S=salinity, T=temperature, A=current speed, and D=current direction.

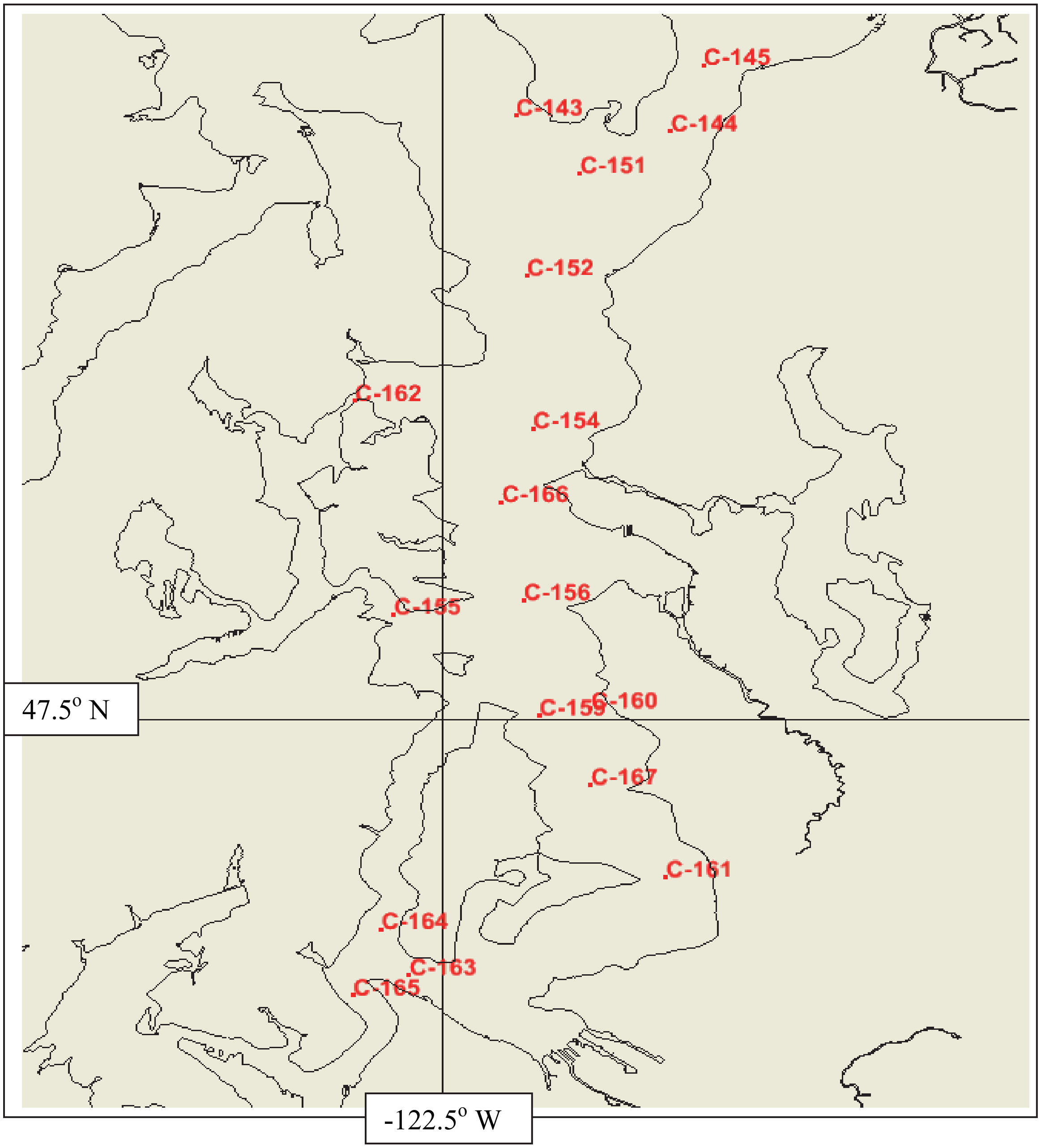


Figure 3.3. Station Locations for Puget Sound Dataset 3.

Table 3.6. Puget Sound Dataset 4.

Station No.	Latitude (°N)	Longitude (°W)	M-Depth (ft)	S-Depth (fathoms)	Measurement Dates mm/dd/yr		Data Length Days	Data Quality STAD
C-167	47.454	122.405	-70	122	10/28/77	11/16/77	19.14	x
C-163	47.322	122.521	-15	50	11/ 1/77	11/16/77	15.09	xx
C-163	47.322	122.521	-70	50	11/ 1/77	11/16/77	15.08	
C-165	47.308	122.557	-19	30	11/ 1/77	11/17/77	15.20	x
C-139	47.963	122.579	-73	50	2/ 3/78	2/20/78	17.95	
C-139	47.963	122.579	-18	50	2/ 3/78	2/22/78	18.06	x
C-171	47.219	122.629	-73	50	3/ 9/78	3/24/78	15.03	xx
C-173	43.153	122.624	-14	n/a	3/ 9/78	3/24/78	15.00	x
C-173	43.153	122.624	-69	n/a	3/ 9/78	3/24/78	15.01	x
C-173	43.153	122.624	20	n/a	3/ 9/78	3/24/78	15.01	x
C-172	47.277	122.711	-15	40	3/ 9/78	3/24/78	15.01	
C-172	47.277	122.711	-70	40	3/ 9/78	3/24/78	15.01	
C-172	47.277	122.711	50	40	3/ 9/78	3/24/78	15.01	x
C-171	47.219	122.629	-18	50	3/ 9/78	3/24/78	15.03	x
C-171	47.219	122.629	-73	50	3/ 9/78	3/24/78	15.03	xx
C-171	47.219	122.629	50	50	3/ 9/78	3/24/78	15.05	x
C-169	47.224	122.584	-16	36	3/ 9/78	3/24/78	15.02	x
C-169	47.224	122.584	-71	36	3/ 9/78	3/24/78	15.02	
C-169	47.224	122.584	50	36	3/ 9/78	3/25/78	15.38	x
C-170	47.257	122.602	-15	20	3/ 9/78	3/28/78	18.83	x
C-170	47.257	122.602	-70	20	3/ 9/78	3/28/78	18.87	x
C-170	47.257	122.602	20	20	3/ 9/78	3/28/78	18.87	x
C-168	47.262	122.557	-16	25	3/ 9/78	3/30/78	20.08	
C-168	47.262	122.557	-71	25	3/ 9/78	3/29/78	20.10	x x
C-168	47.262	122.557	50	25	3/ 9/78	3/29/78	20.09	x
C-176	47.118	122.705	-15	20	3/23/78	4/10/78	18.01	x
C-176	47.118	122.705	-70	20	3/ 8/78	4/10/78	32.99	x
C-176	47.118	122.705	50	20	3/ 8/78	4/10/78	33.01	x
C-179	47.166	122.862	-18	16	3/ 9/78	4/11/78	33.03	x
C-179	47.166	122.862	-73	16	3/ 8/78	4/ 2/78	24.76	
C-179	47.166	122.862	20	16	3/ 8/78	4/10/78	33.03	
C-174	47.161	122.657	-71	75	3/28/78	4/13/78	15.76	
C-174	47.161	122.657	50	75	3/28/78	4/13/78	15.82	x
C-177	47.190	122.731	-17	20	3/27/78	4/12/78	15.80	
C-177	47.190	122.731	-72	20	3/27/78	4/12/78	15.80	x
C-177	47.190	122.731	50	20	3/27/78	4/12/78	15.78	x
C-178	47.168	122.789	-14	40	3/27/78	4/12/78	15.82	x
C-178	47.168	122.789	-69	40	3/27/78	4/12/78	15.83	x
C-178	47.168	122.789	50	40	3/27/78	4/12/78	15.83	x
C-180	47.231	122.835	-16	27	3/28/78	4/12/78	15.01	x
C-180	47.231	122.835	-71	27	3/28/78	4/12/78	15.01	x
C-180	47.231	122.835	20	27	3/28/78	4/12/78	15.01	x
C-181	47.301	122.862	-18	12	3/28/78	4/12/78	15.02	x
C-181	47.301	122.862	20	12	3/28/78	4/12/78	15.03	x
C-165	47.310	122.557	-15	30	3/ 8/78	4/10/78	33.00	xxxx
C-165	47.310	122.557	50	30	3/ 8/78	4/10/78	32.99	x
C-96	48.252	124.130	-69	85	10/ 3/78	11/ 2/78	29.36	x
C-96	48.252	124.130	50	85	10/ 2/78	11/ 2/78	30.06	x

Notes: M-Depth=measurement depth with respect to MLLW, where positive numbers are distance above the bottom and negative numbers are distance below the surface. S-Depth=station depth with respect to MLLW. Note x denotes bad data within the STAD station matrix where S=salinity, T=temperature, A=current speed, and D=current direction.

Table 3.6. Puget Sound Dataset 4 (cont.).

Station No.	Latitude (°N)	Longitude (°W)	M-Depth (ft)	S-Depth (fathoms)	Measurement Dates mm/dd/yr		Data Length Days	Data Quality STAD
C-89	48.176	123.574	-14	35	10/ 3/78	11/ 2/78	30.05	
C-89	48.176	123.574	-69	35	10/ 3/78	11/ 2/78	30.04	
C-89	48.176	123.574	50	35	10/ 3/78	11/ 2/78	30.03	x
C-97	48.300	124.079	-14	100	10/ 2/78	11/ 1/78	30.03	x
C-97	48.300	124.079	-69	100	10/ 2/78	11/ 1/78	30.01	x

Notes: M-Depth=measurement depth with respect to MLLW, where positive numbers are distance above the bottom and negative numbers are distance below the surface. S-Depth=station depth with respect to MLLW. Note x denotes bad data within the STAD station matrix where S=salinity, T=temperature, S=current speed, and D=current direction.

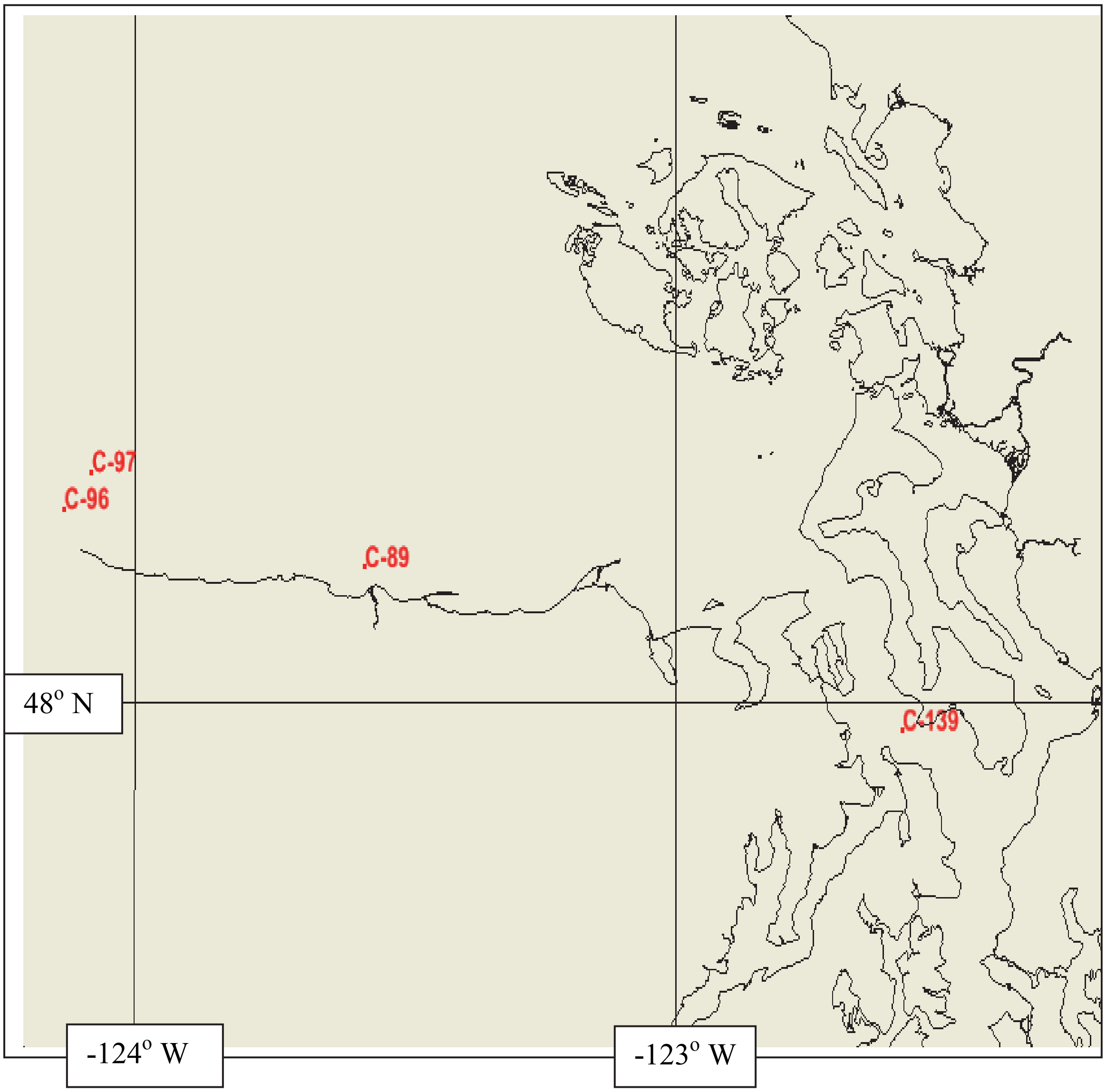


Figure 3.4. Puget Sound Station Locations for Dataset 4 North

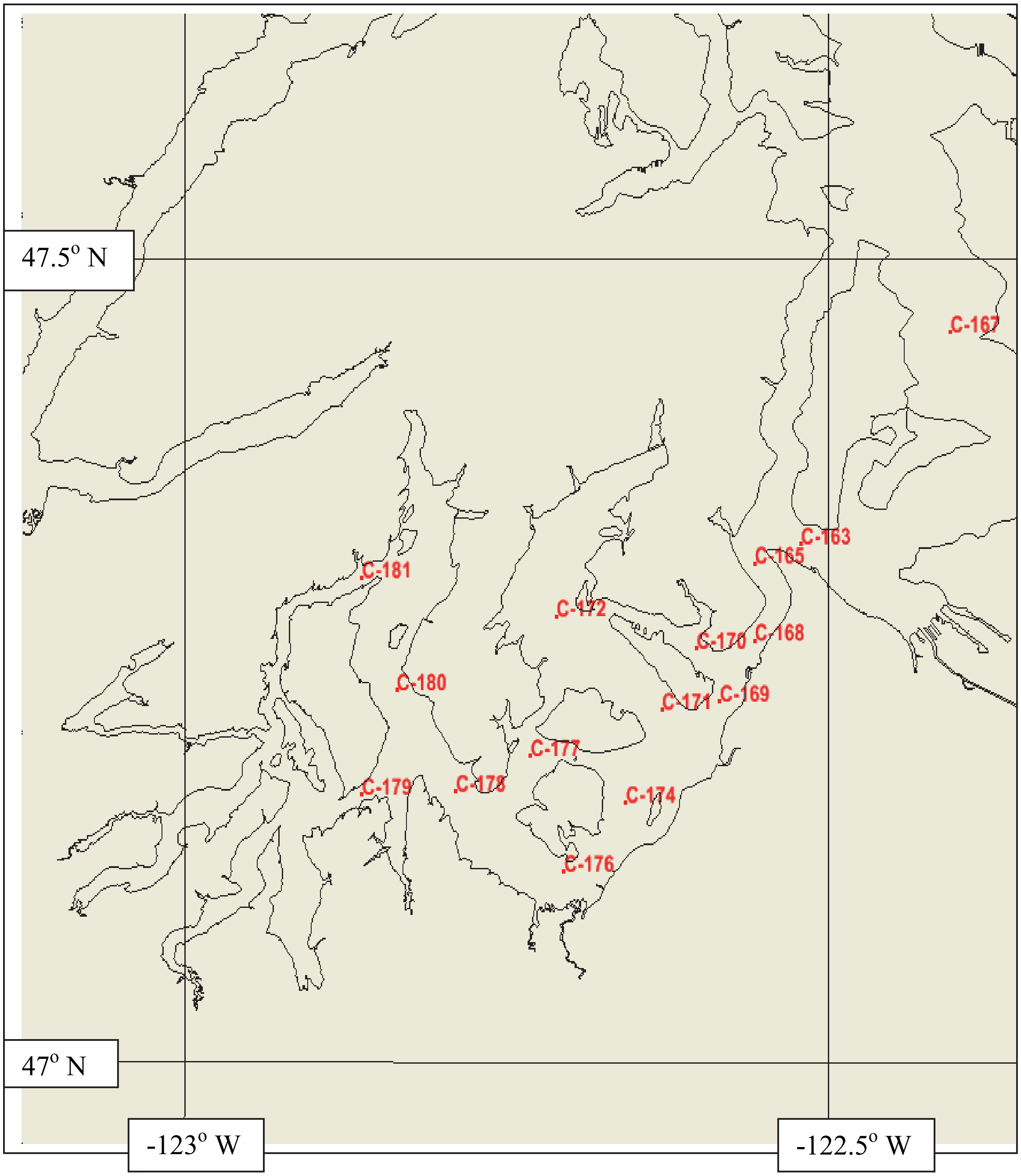


Figure 3.5. Puget Sound Station Locations for Dataset 4 South

Regional Oceanographic Considerations

From Wikipedia (http://en.wikipedia.org/wiki/Puget_Sound), we present an overview of the major characteristics of Puget Sound in this and the following paragraph. Puget Sound is a complex system in the State of Washington of interconnected marine waterways and basins. It has one major and one minor connection to the Strait of Juan de Fuca and the Pacific Ocean. Puget Sound extends approximately 100 miles from Deception Pass in the north to Olympia, Washington, in the south. The average depth of the sound is 205 feet and its maximum depth, off Point Jefferson, is 930 feet. The depth of the main basin, between the southern tip of Whidbey Island and Tacoma, Washington, is approximately 600 feet.

Puget Sound is a large salt water estuary, or system of estuaries, fed by highly seasonal freshwater from the Olympic and Cascade Mountain watersheds. The mean annual river discharge into Puget Sound is 41,000 cubic feet per second. The monthly average maximum is about 367,000 cubic feet per second, and the monthly average minimum is about 14,400 cubic feet per second. Puget Sound's shoreline is 1,332 miles long with a total volume of 26.5 cubic miles at mean high water. The Puget Sound system consists of four deep basins connected by shallower sills. The four basins are Hood Canal, Whidbey Basin, South Sound, south of the Tacoma Narrows, and the Main Basin, which is further subdivided into Admiralty Inlet and the Central Basin. There are three sills of significant importance. The one sill at Admiralty Inlet checks the flow of water between the Strait of Juan de Fuca and Puget Sound, a second sill at the entrance to Hood Canal, and the third sill located at the Tacoma Narrows. The average volume of water flowing in and out of Puget Sound during each tide is 1.26 cubic miles. The maximum tidal currents are in the range of about 9 to 10 knots, which occurs at Deception Pass. Tides are of the mixed type with two high and two low tides each tidal day. The configuration of basin, sills, and interconnections cause the tidal range to increase within Puget Sound. The difference between the Higher High Water and the Lower Low Water averages 0.091m at Port Townsend on Admiralty Inlet, but increased to 4.4m at Olympia, at the southern end of Puget Sound.

An overview of the circulation is given by Cannon (1983) and focuses on deep-water replacement, mean current profiles, and coastal interactions. Deep-water replacement is controlled by the 31 km entrance sill. Once intrusion enters the basin, it propagates as a temperature change followed by an up-estuary current pulse and then as a maximum in salinity and density. Tidally averaged longitudinal currents indicate a depth of no-net-motion along-channel in the range of 40-60m. However, wind effects can cause significant variation in these depths. Because Puget Sound connects with the Pacific Ocean through the Strait of Juan de Fuca, the circulation in the Strait is influenced by the major freshwater inflow from the Fraser River at Vancouver, BC, which in turn influences the circulation in Puget Sound.

Here we examine CT and current time series for representative stations in each of the four datasets, generally proceeding from the entrance at the North to the South. Starting with Station C-63 in dataset 1 during the Fall of 1976, we consider salinity and temperature at 13 ft (Figure 3.6) and 68 ft (Figure 3.8) below the surface, and at 50 ft above the bottom (Figure 3.10), respectively. We note that salinity and temperature increase and decrease with depth, respectively. Current speed and direction are given at the Station C-63 at the corresponding depths in Figures 3.7, 3.9, and 3.11, respectively. One notes that while the signals are noisy, current speeds decrease with depth with directions being relatively uniform.

At Station C-149 in dataset 2 during late Winter and early Spring 1977, temperature at 15 ft (Figure 3.12), and 70 ft (Figure 3.14) below the surface, and at 50 ft above the bottom (Figure 3.16), respectively, are shown. We note that no salinity data are available and temperatures are relatively uniform with depth. We note that at both stations, there is less noise in the signals at 50 ft above the bottom, than at the surface depths. Current speed and directions at the corresponding depths are shown in Figures 3.13, 3.15, and 3.17, respectively. Current speeds decrease with depth, while current directions are relatively noisy.

For dataset 3, we consider Station C-155 during September 1977 at 22 feet below the surface with temperature given in Figure 3.18 (no salinity is available). Temperature ranges by order 1^{o}C over the day. Current speed and direction are shown in Figure 3.19, with peak speeds reaching 70 cm/s within a rectilinear flow.

For dataset 4, we consider two stations. Station C-89 is in the Strait of Juan de Fuca with salinity and temperature in October 1978 shown in Figures 3.20, 3.22, and 3.24, at 14 ft and 69 ft below the surface and at 50 ft above the bottom, respectively. Salinity is seen to increase with depth, while temperature is nearly uniform. Current speed and direction are shown at the corresponding depths in Figures 3.21, 3.23, and 3.25, respectively. Current speeds and directions are relatively uniform over depth. At Station C-180 in the lower Puget Sound, we consider temperature responses in March 1978 at 16 ft and 71 ft below the surface, and 20 ft above the bottom in Figures 3.26, 3.28, and 3.30, respectively. Current speed and direction responses are shown at the corresponding depths in Figures 3.27, 3.29, and 3.31, respectively. Note that no salinity data were available at this station and current speed and direction are nearly uniform over depth.

One notes the lack of salinity data at several stations, and the noise in the signals, which may need further filtering prior to model versus data comparisons.

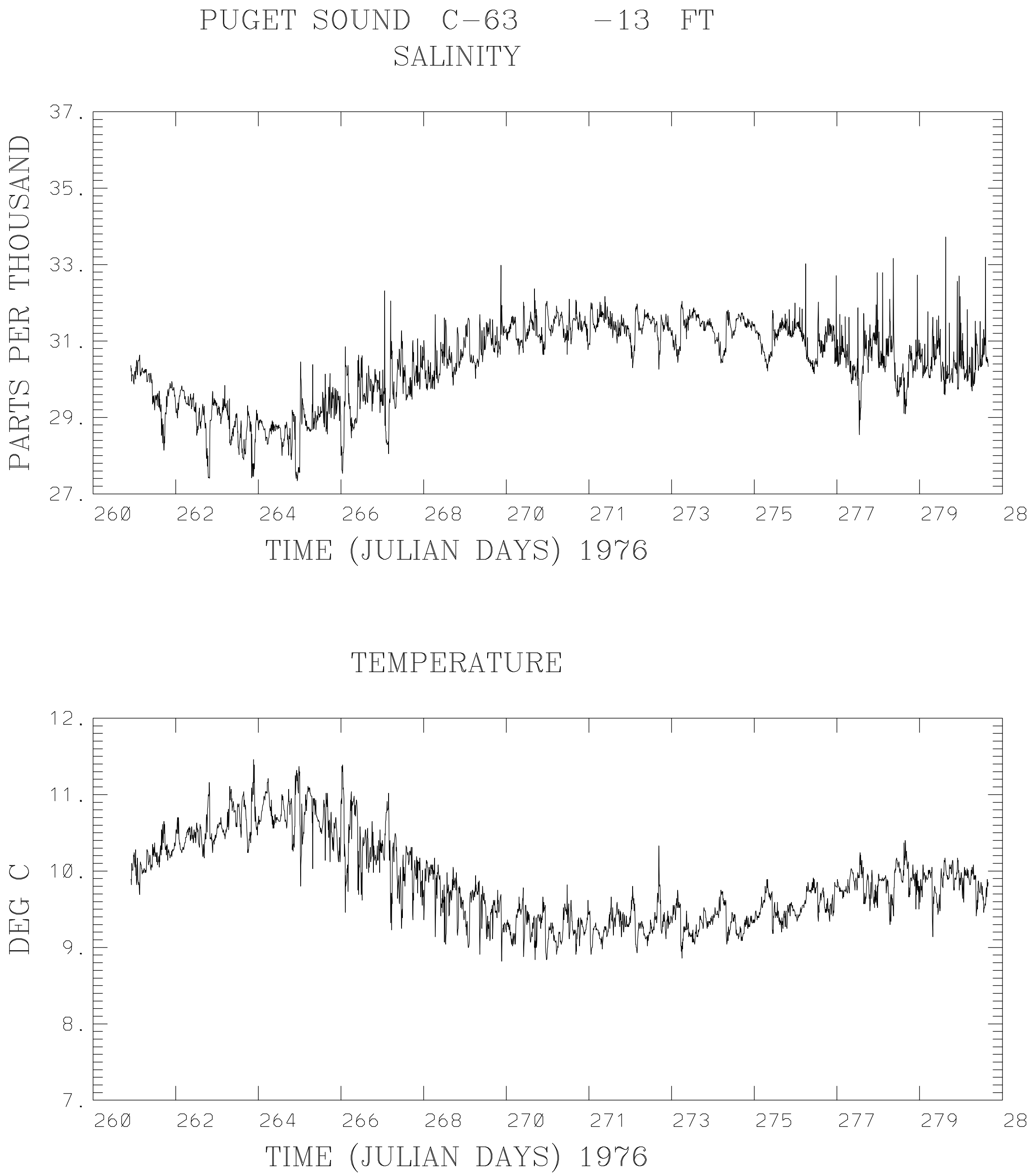


Figure 3.6. Station C-63 Puget Sound Salinity and Temperature at 13 ft below the surface in September 1976.

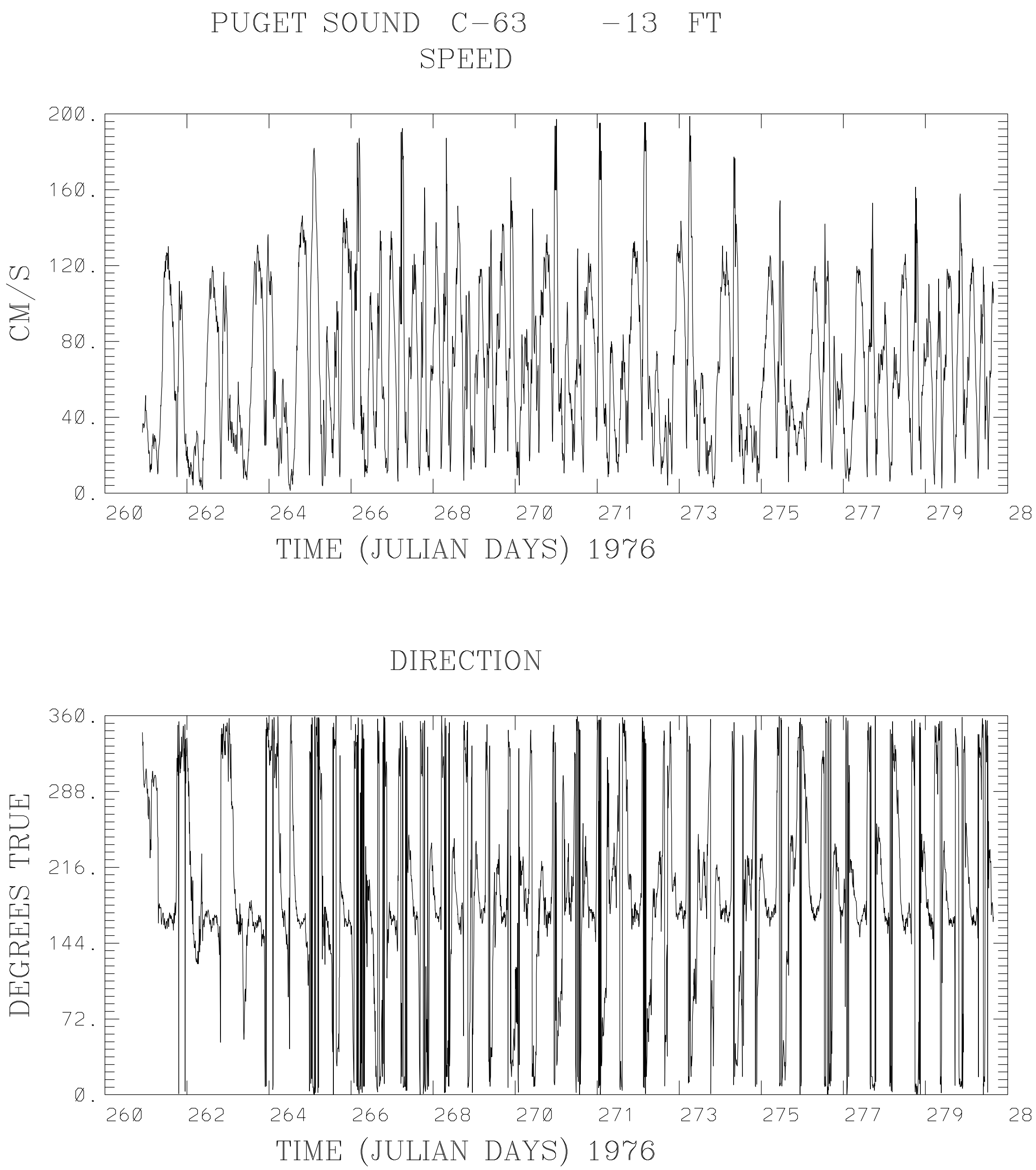


Figure 3.7. Station C-63 Puget Sound Current Speed and Direction at 13 ft below the surface in September 1976.

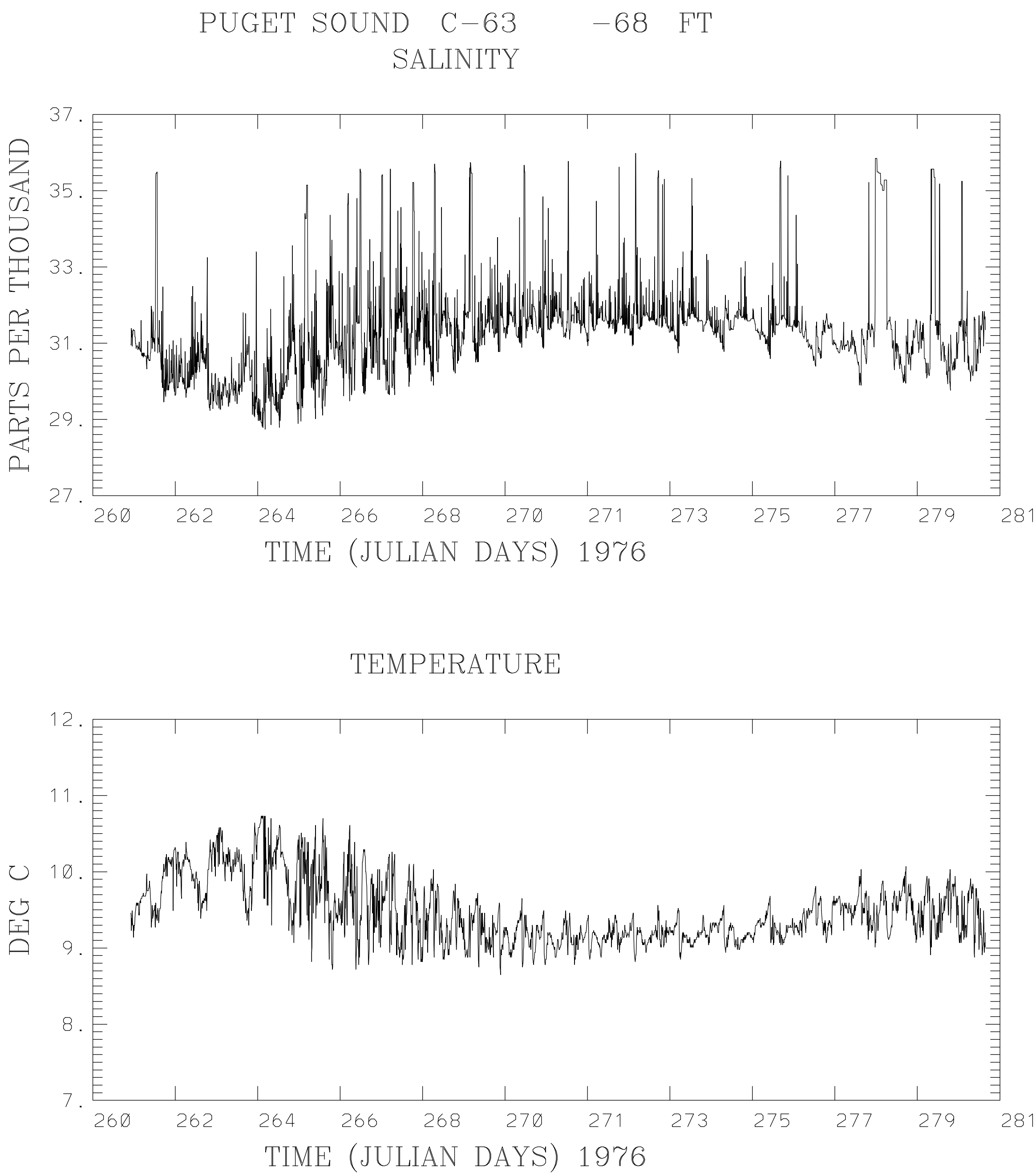


Figure 3.8. Station C-63 Puget Sound Salinity and Temperature at 68 ft below the surface in September 1976.

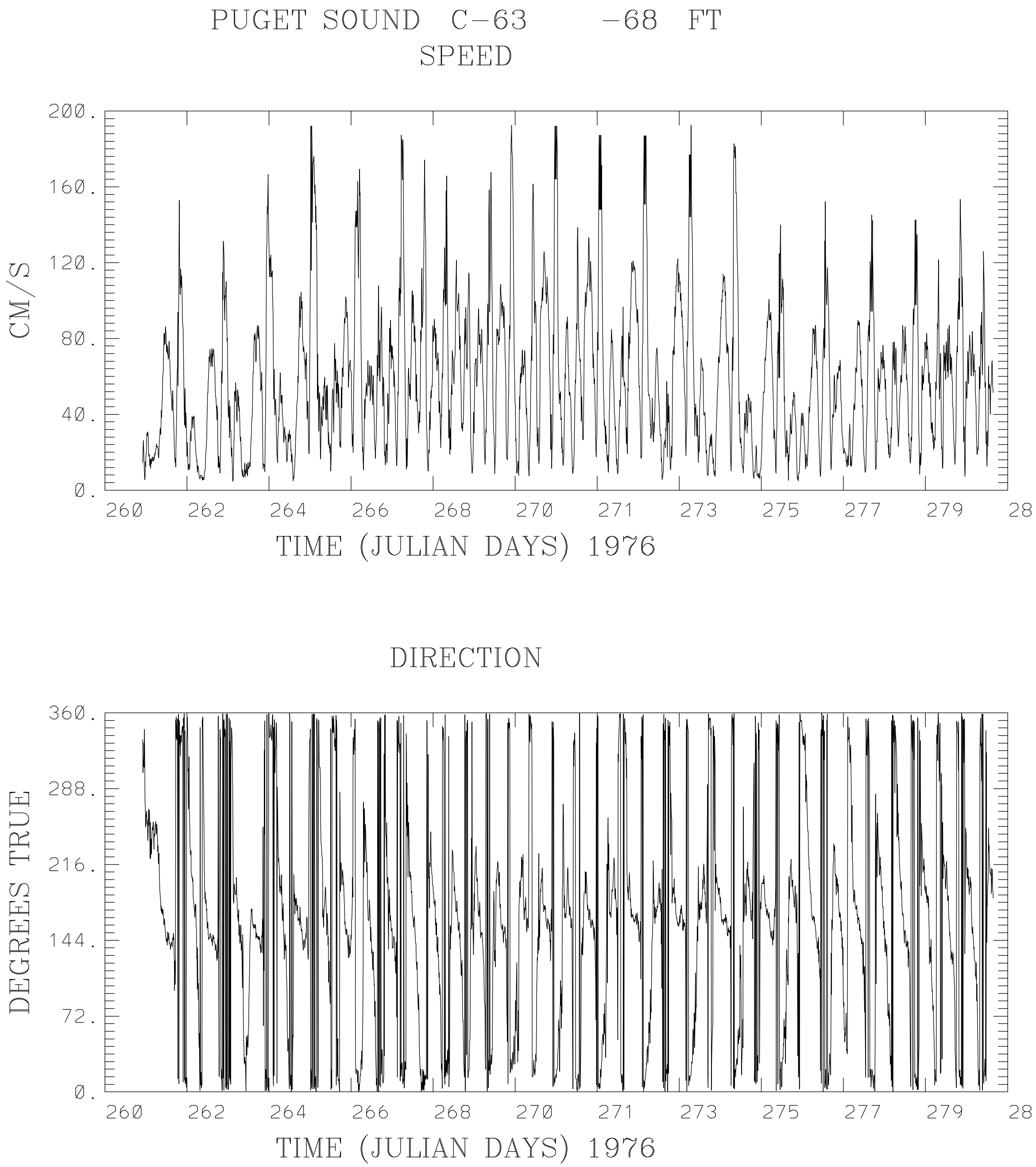


Figure 3.9. Station C-63 Puget Sound Current Speed and Direction at 68 ft below the surface in September 1976.

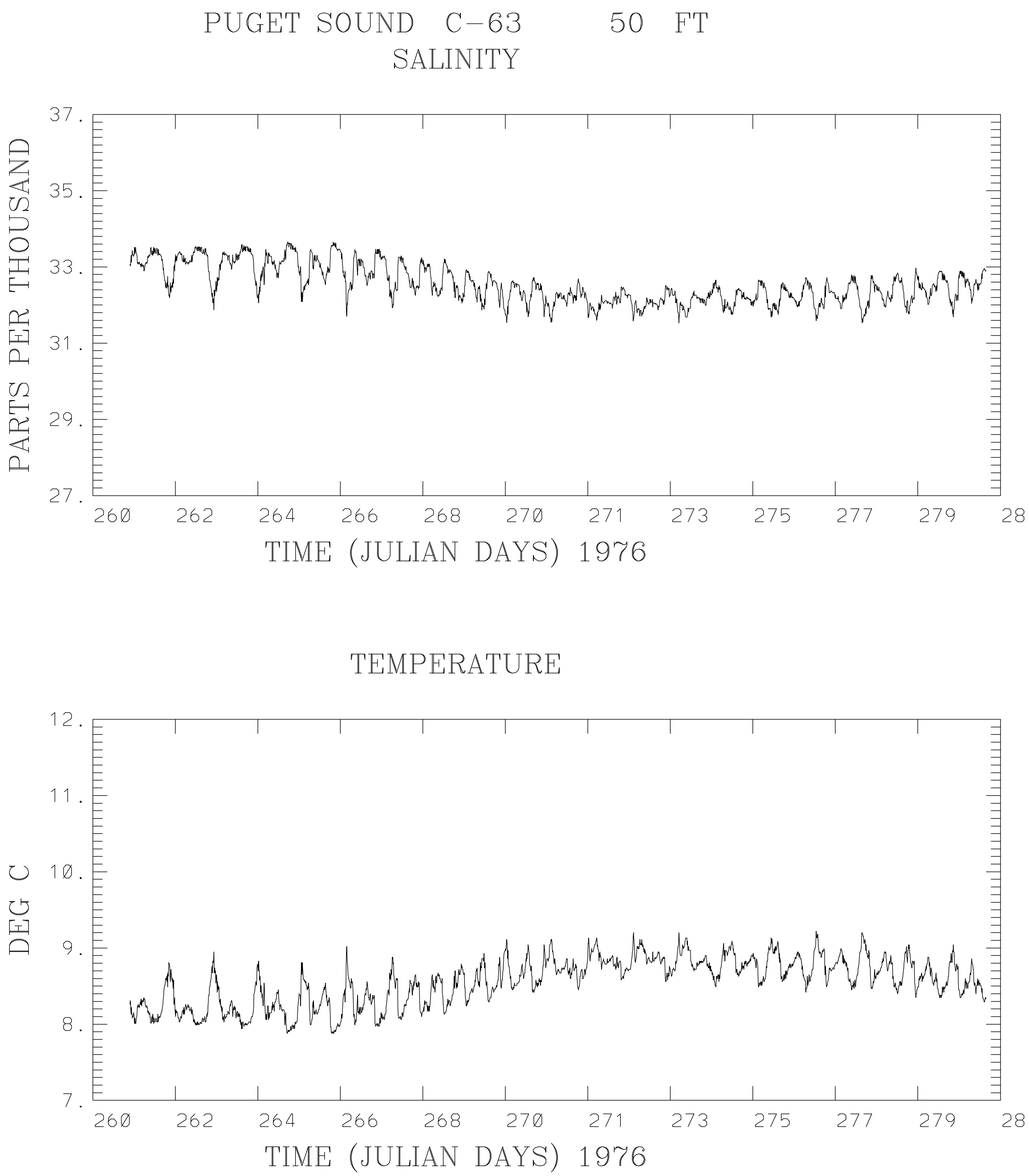


Figure 3.10. Station C-63 Puget Sound Salinity and Temperature at 50 ft above the bottom in September 1976.

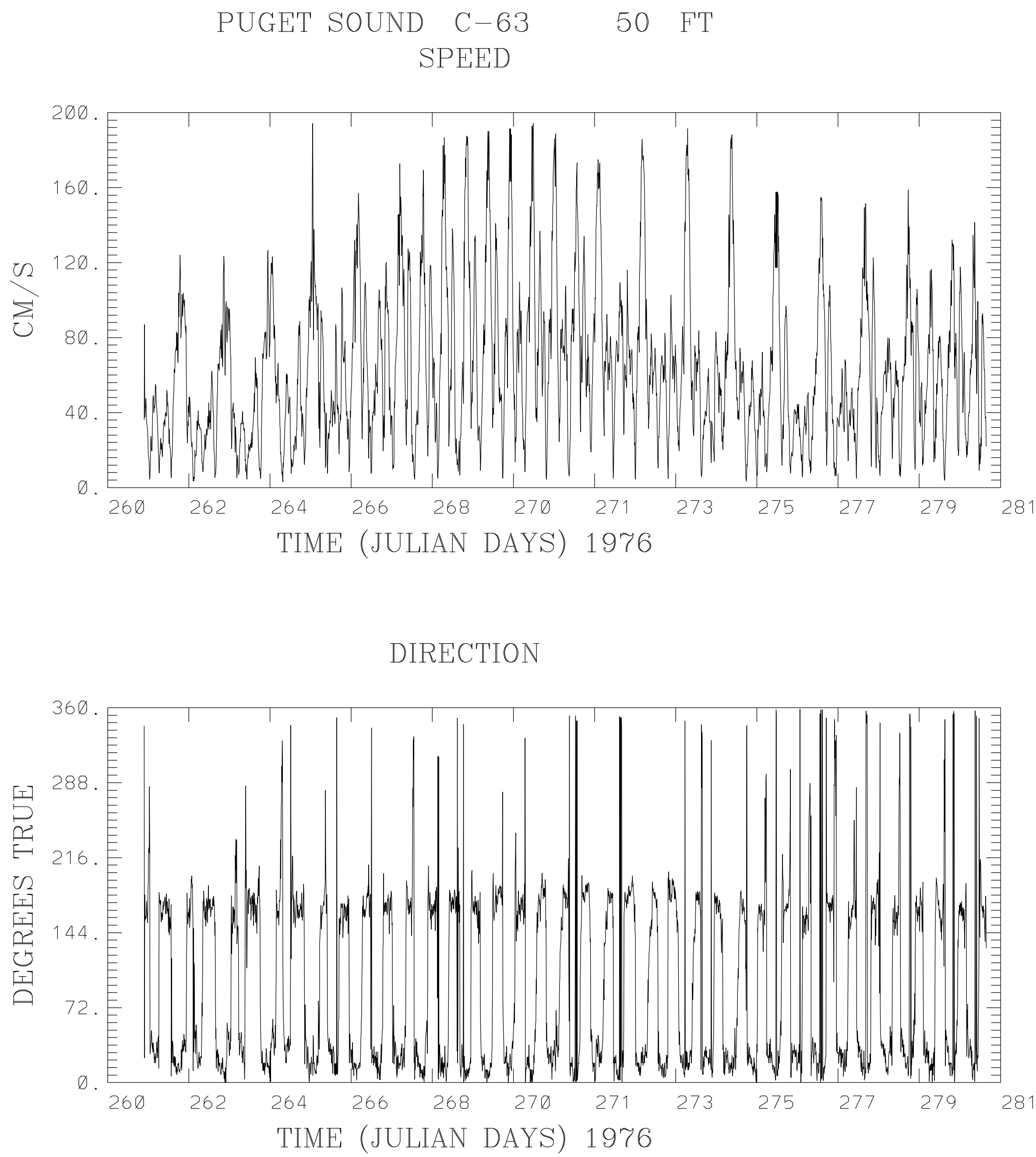


Figure 3.11. Station C-63 Puget Sound Current Speed and Direction at 50 ft above the bottom in September 1976.

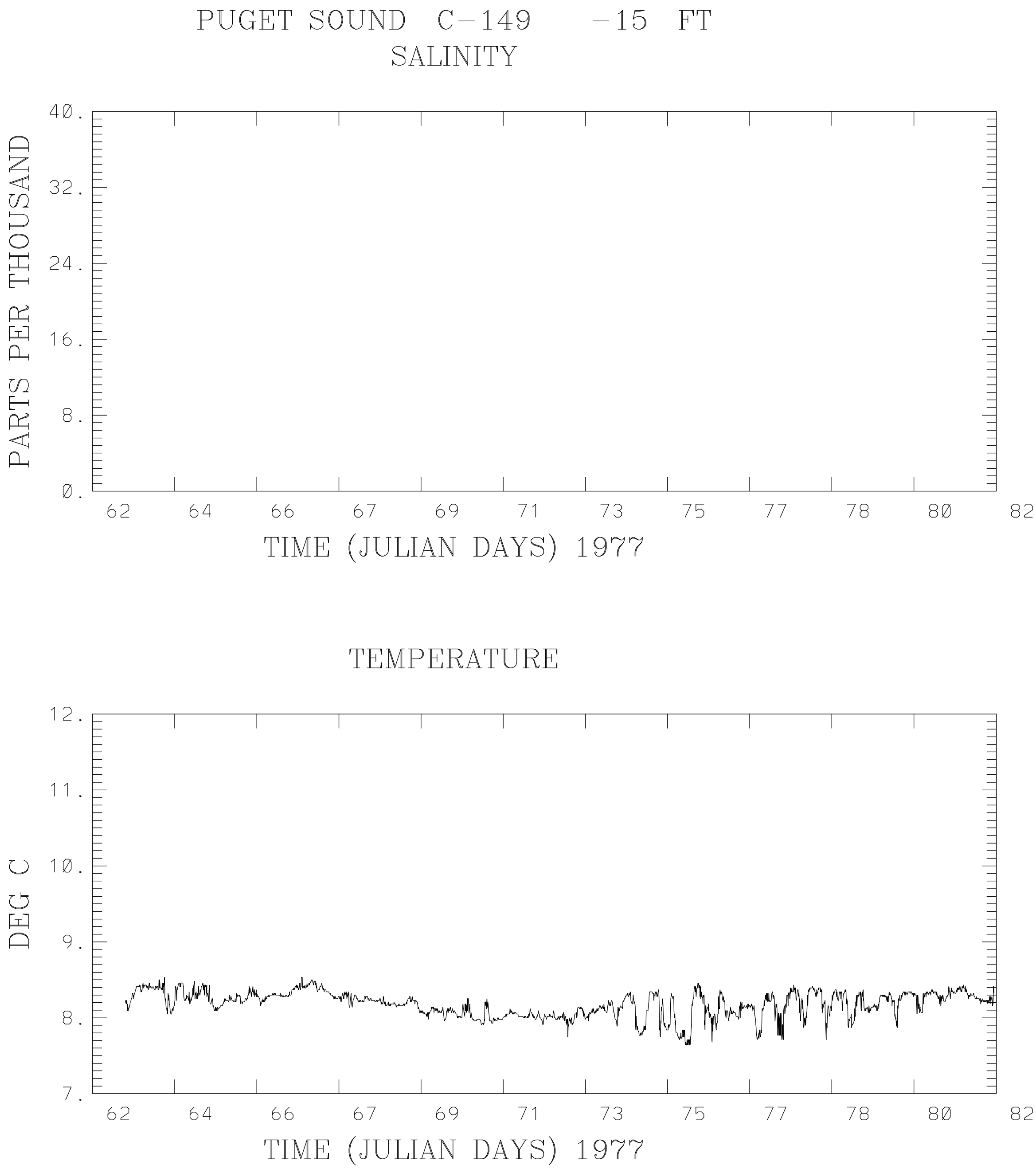


Figure 3.12. Station C-149 Puget Sound Salinity and Temperature at 15 ft below the surface in March 1977. Note from Table 3.4 no salinity data are available at this station.

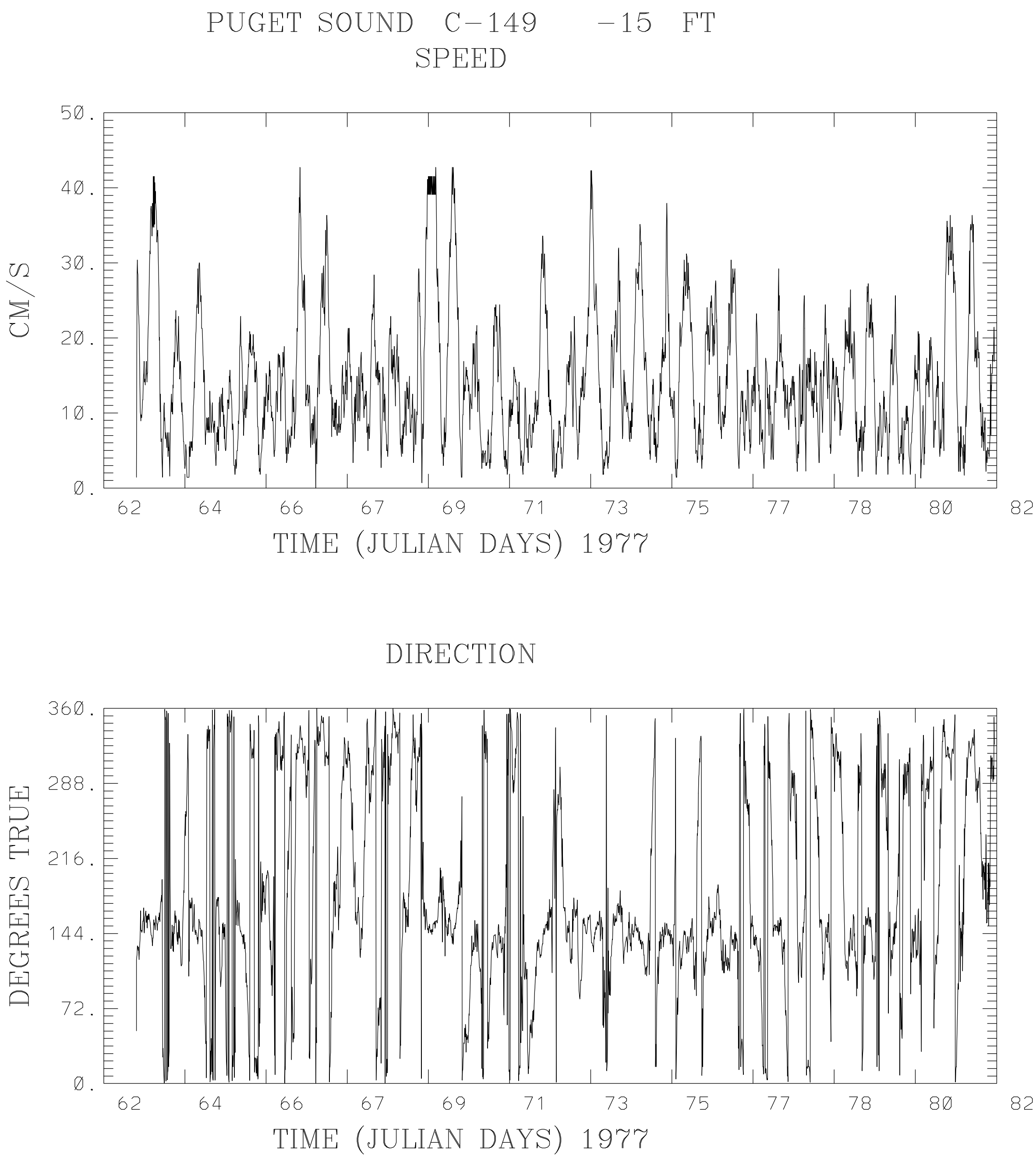


Figure 3.13. Station C-149 Puget Sound Current Speed and Direction at 15 ft below the surface in March 1977.

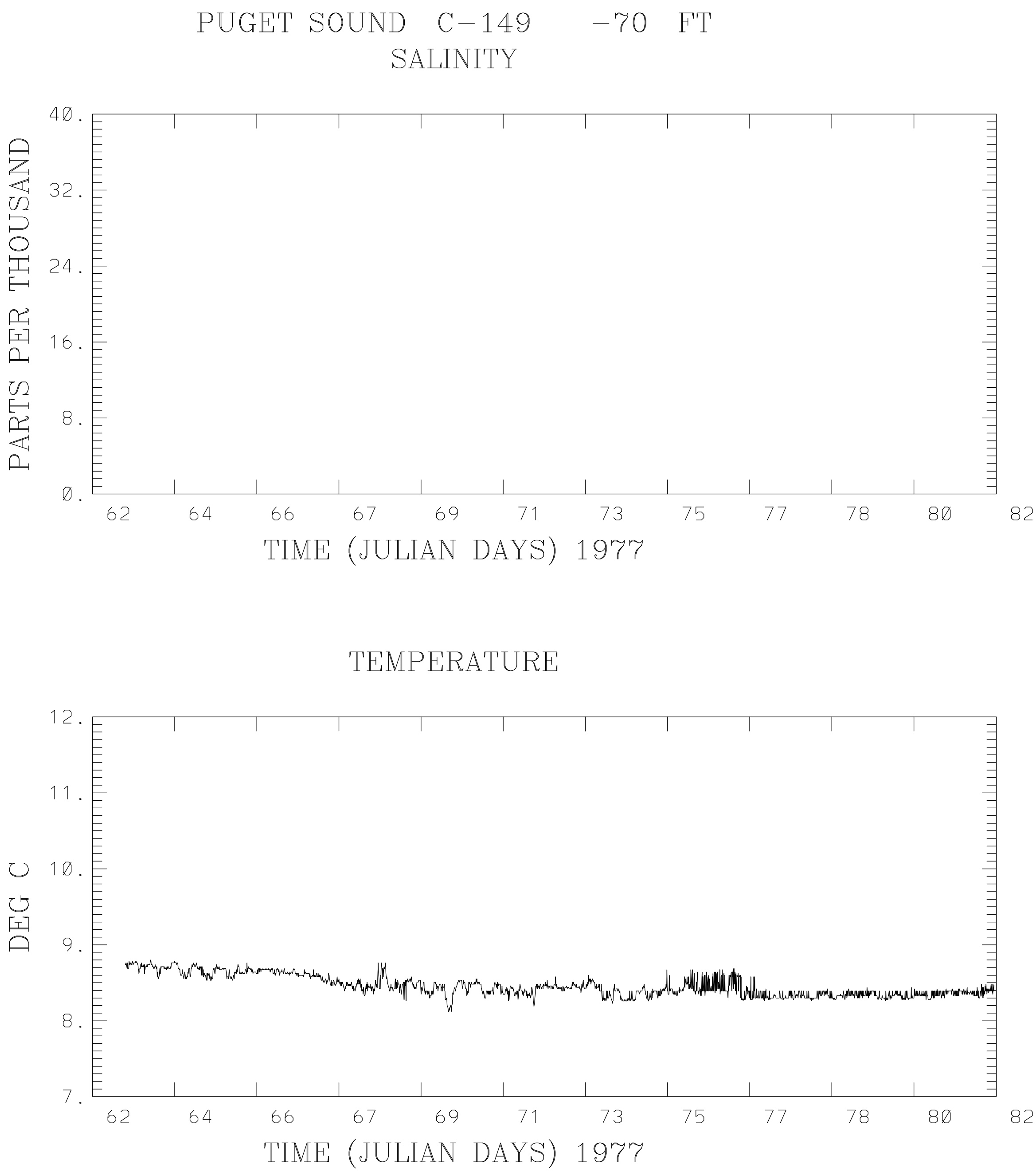


Figure 3.14. Station C-149 Puget Sound Salinity and Temperature at 70 ft below the surface in March 1977. Note from Table 3.4 no salinity data are available at this station.

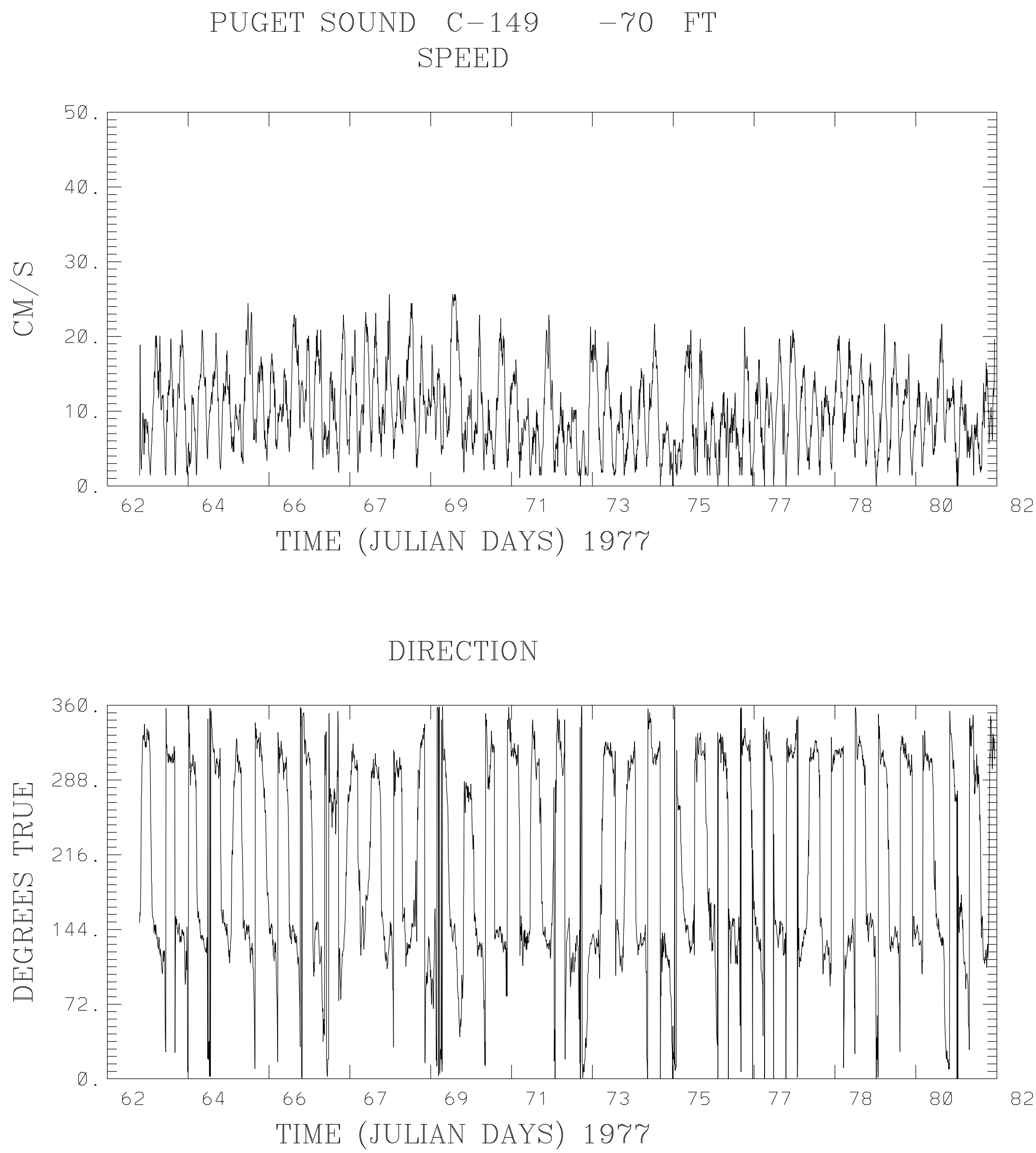


Figure 3.15. Station C-149 Puget Sound Current Speed and Direction at 70 ft below the surface in March 1977.

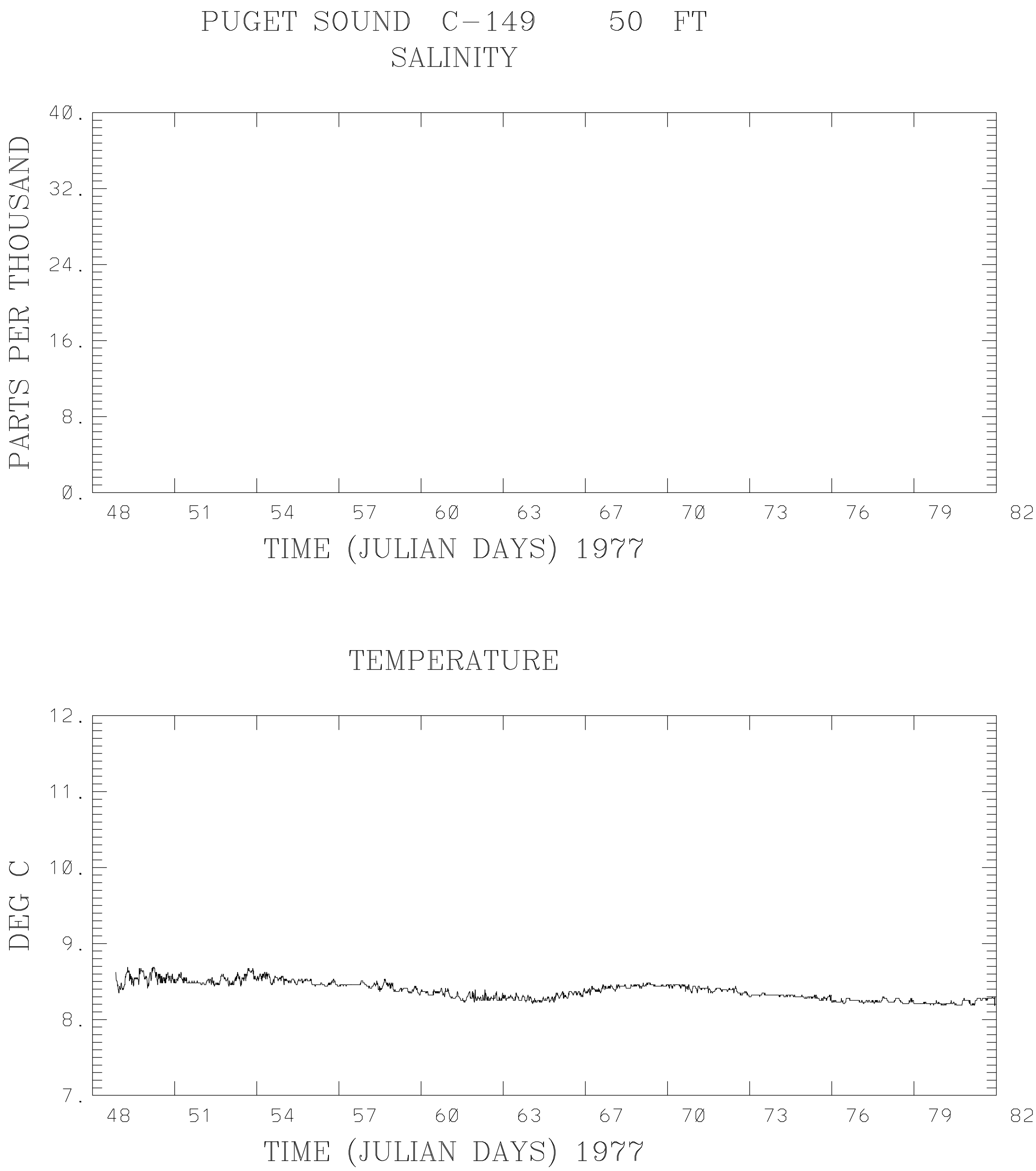


Figure 3.16. Station C-149 Puget Sound Salinity and Temperature at 50 ft above the bottom in February 1977. Note from Table 3.4, no salinity data are available at this station.

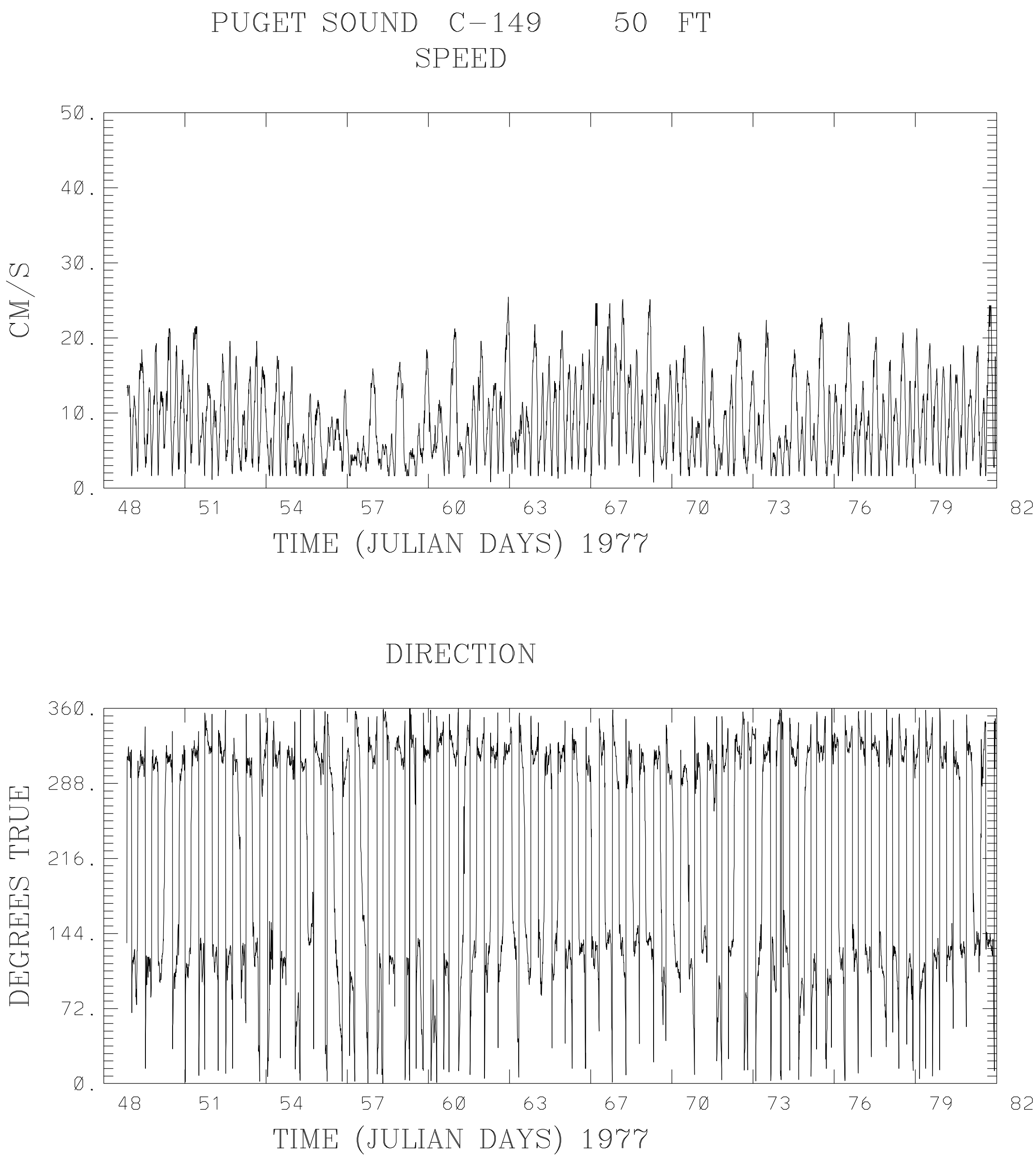


Figure 3.17. Station C-149 Puget Sound Current Speed and Direction at 50 ft above the bottom in February 1977.

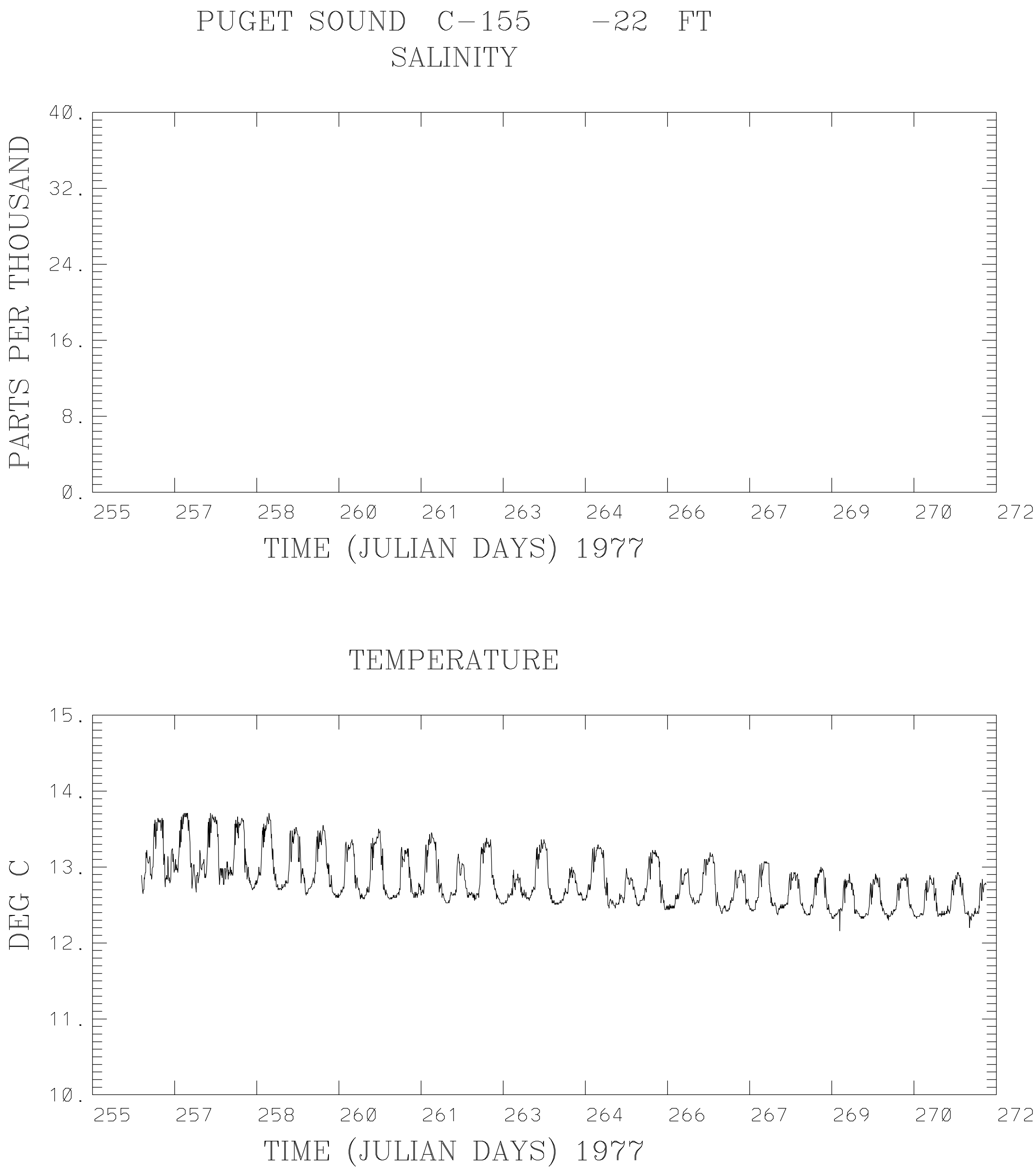


Figure 3.18. Station C-155 Puget Sound Salinity and Temperature at 22 ft below the surface in September 1977. Note from Table 3.5 no salinity data are available at this station.

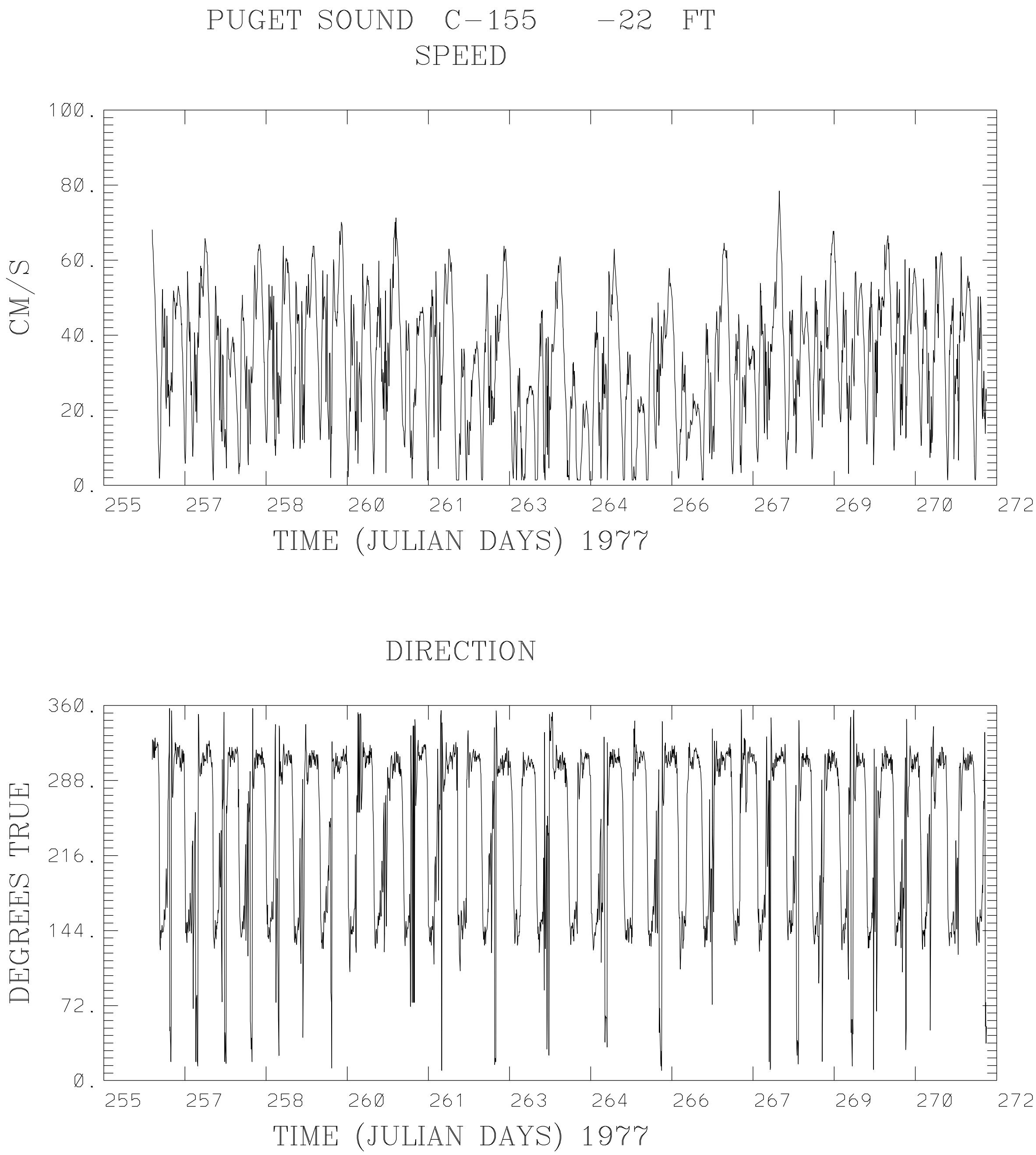
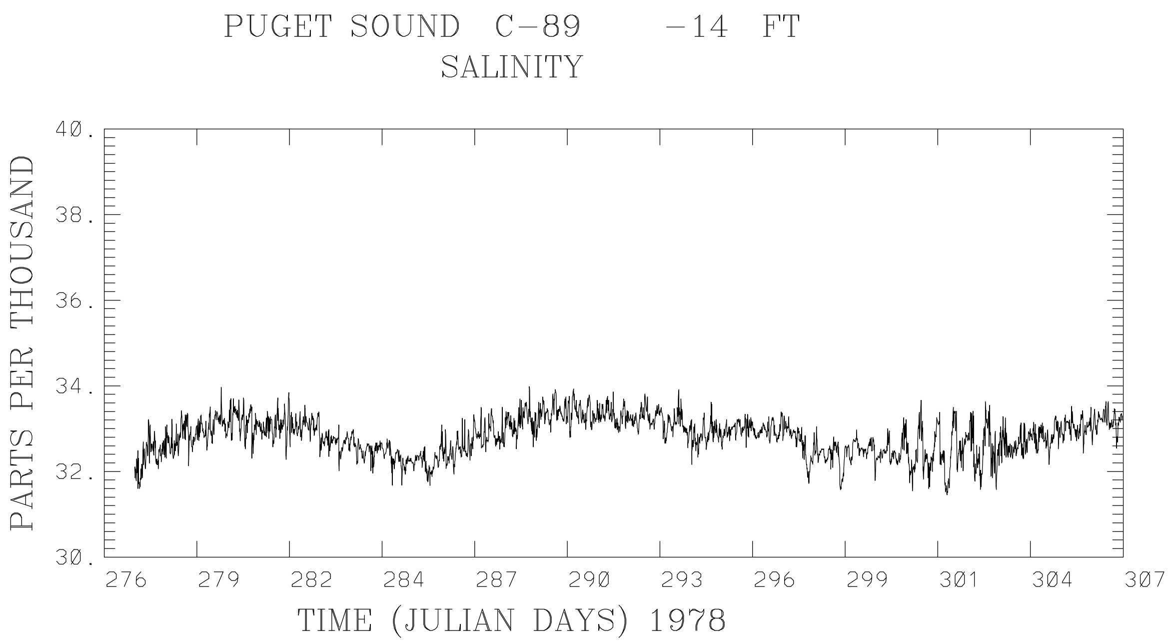


Figure 3.19. Station C-155 Puget Sound Current Speed and Direction at 22 ft below the surface in September 1977.



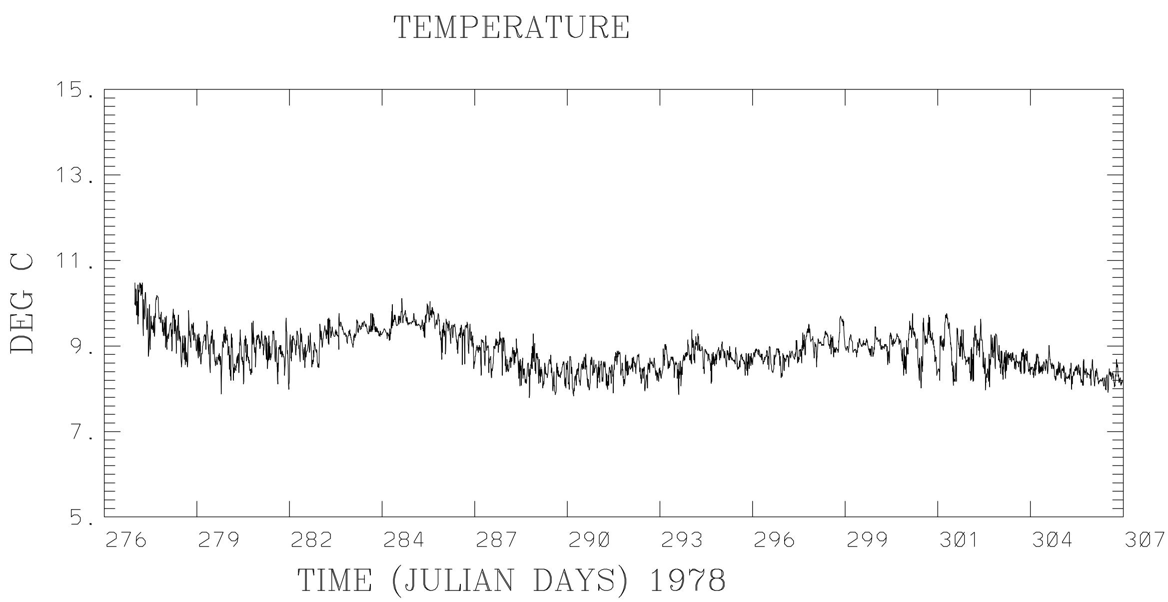


Figure 3.20. Station C-89 Puget Sound Salinity and Temperature at 14 ft below the surface in October 1978.

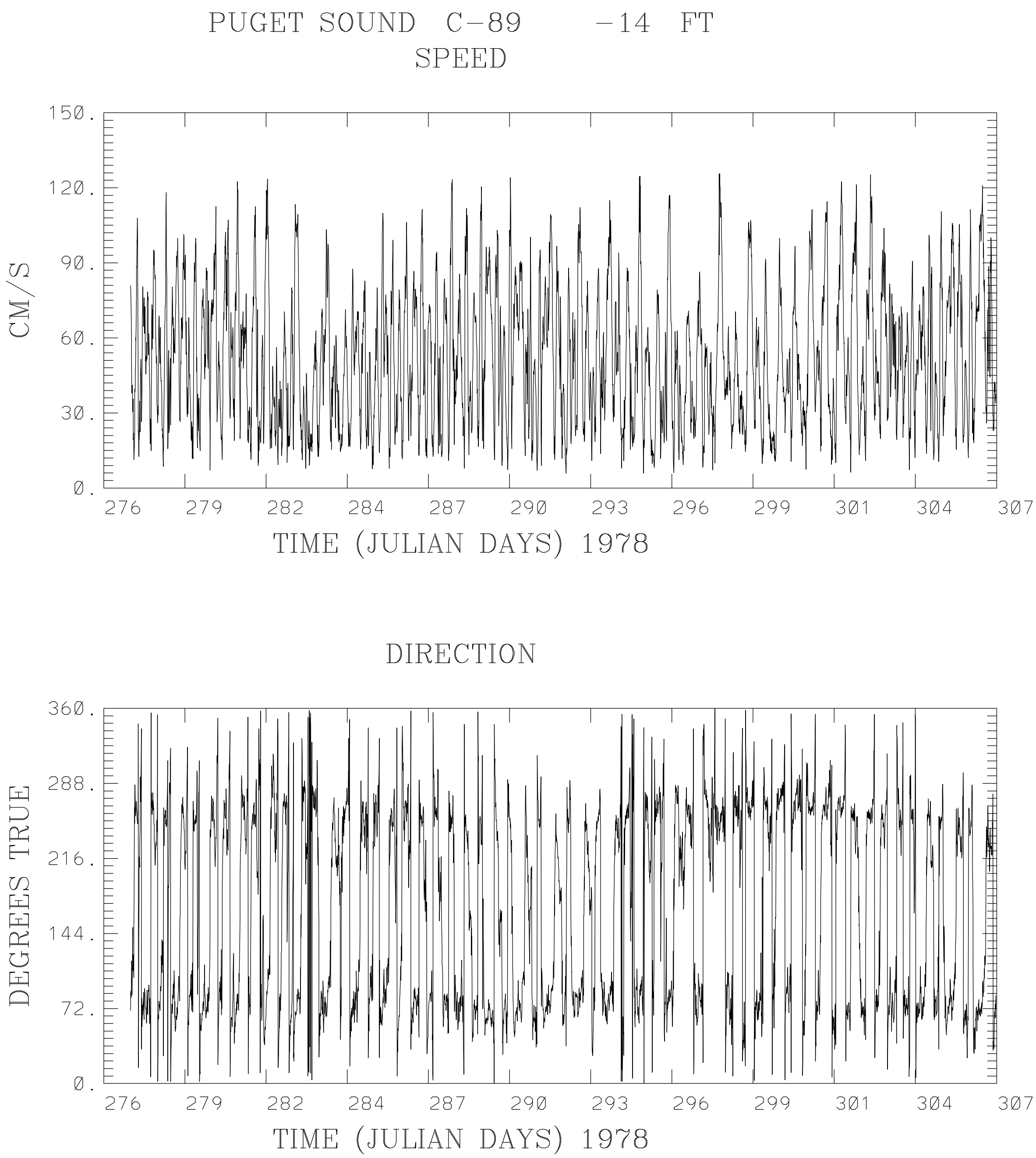


Figure 3.21. Station C-89 Puget Sound Current Speed and Direction at 14 ft below the surface in October 1978.

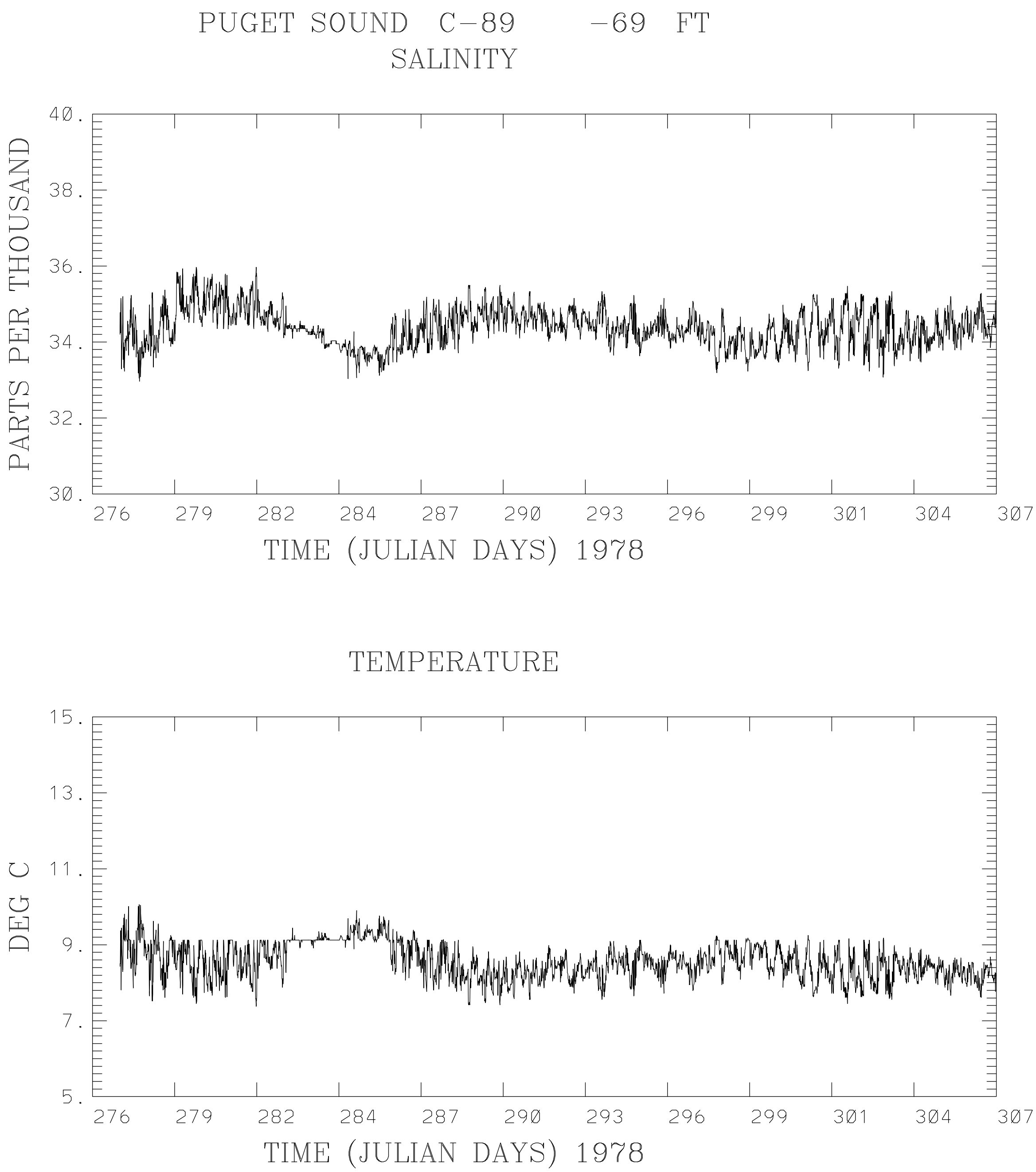


Figure 3.22. Station C-89 Puget Sound Salinity and Temperature at 69 ft below the surface in October 1978.

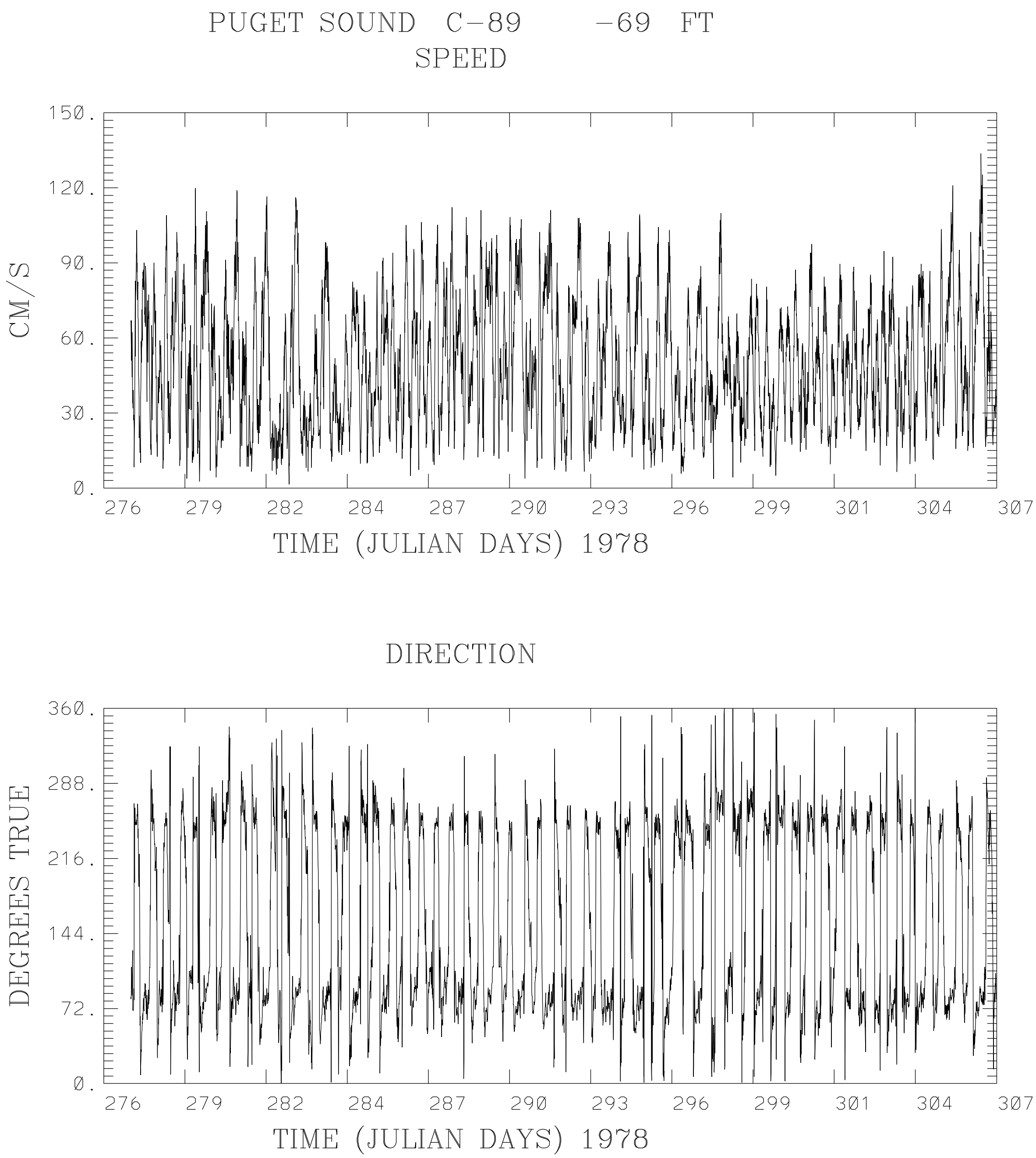
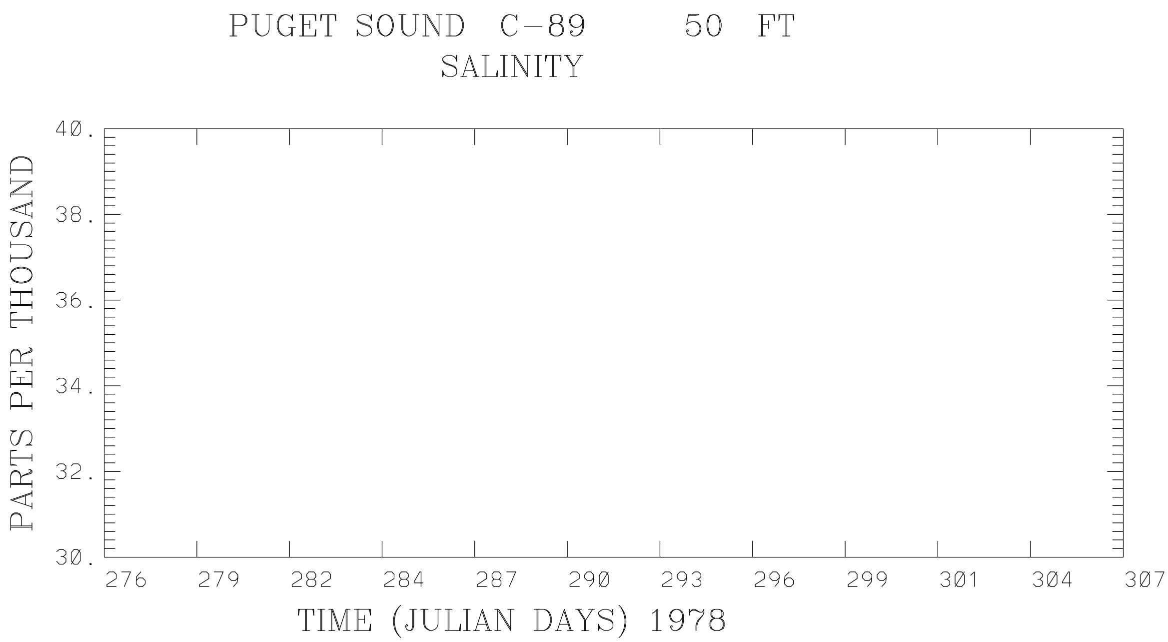


Figure 3.23. Station C-89 Puget Sound Current Speed and Direction at 69 ft below the surface in October 1978.



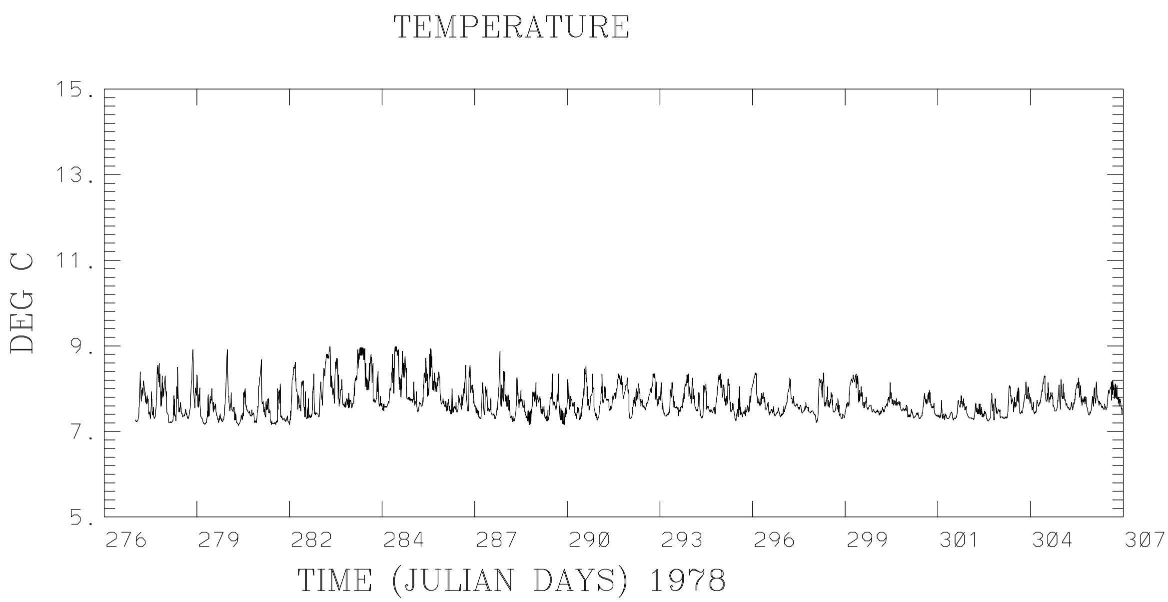


Figure 3.24. Station C-89 Puget Sound Salinity and Temperature at 50 ft above the bottom in September 1978. Note from Table 3.6 no salinity data are available at this station.

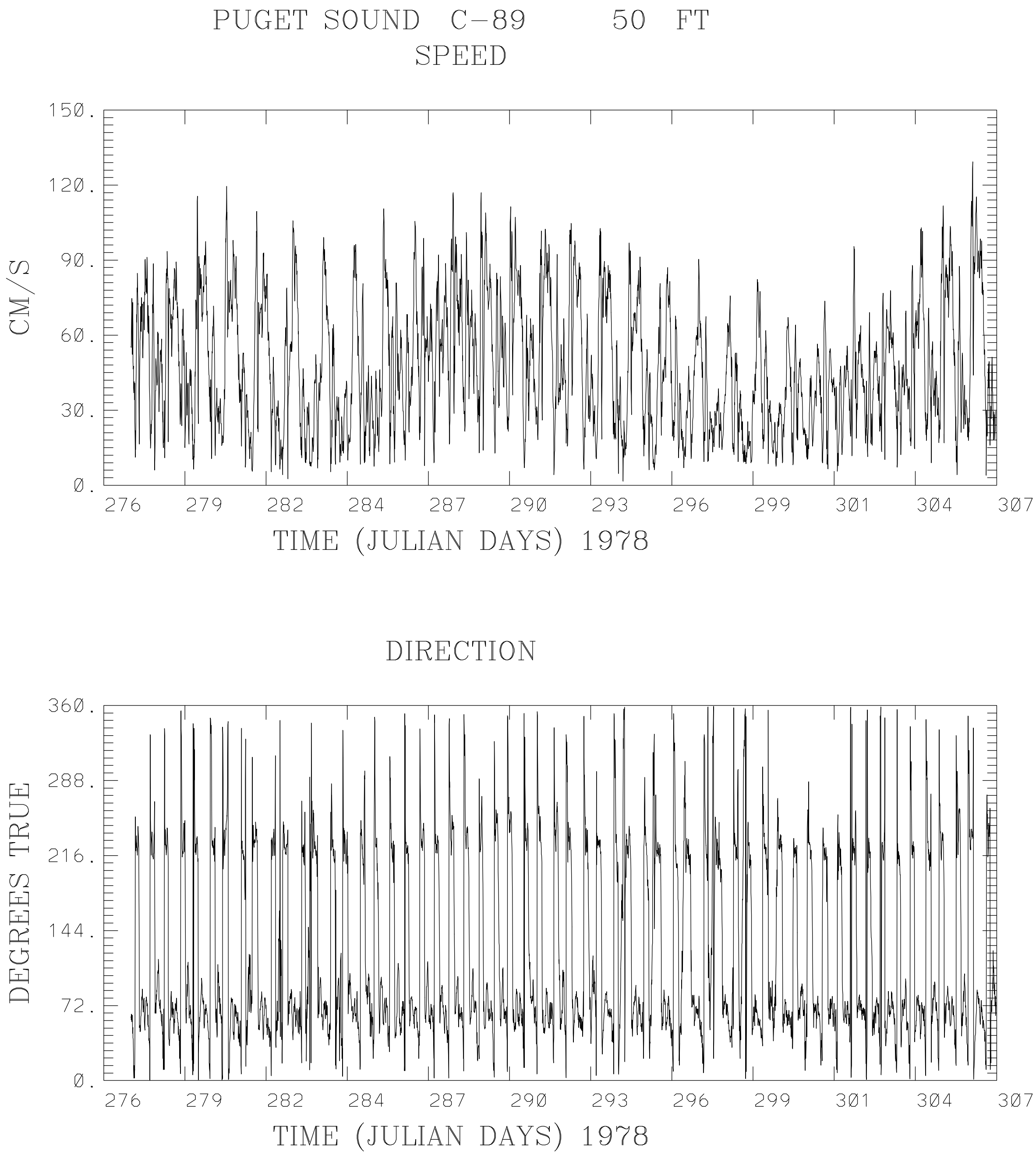


Figure 3.25. Station C-89 Puget Sound Current Speed and Direction at 50 ft above the bottom in September 1978.

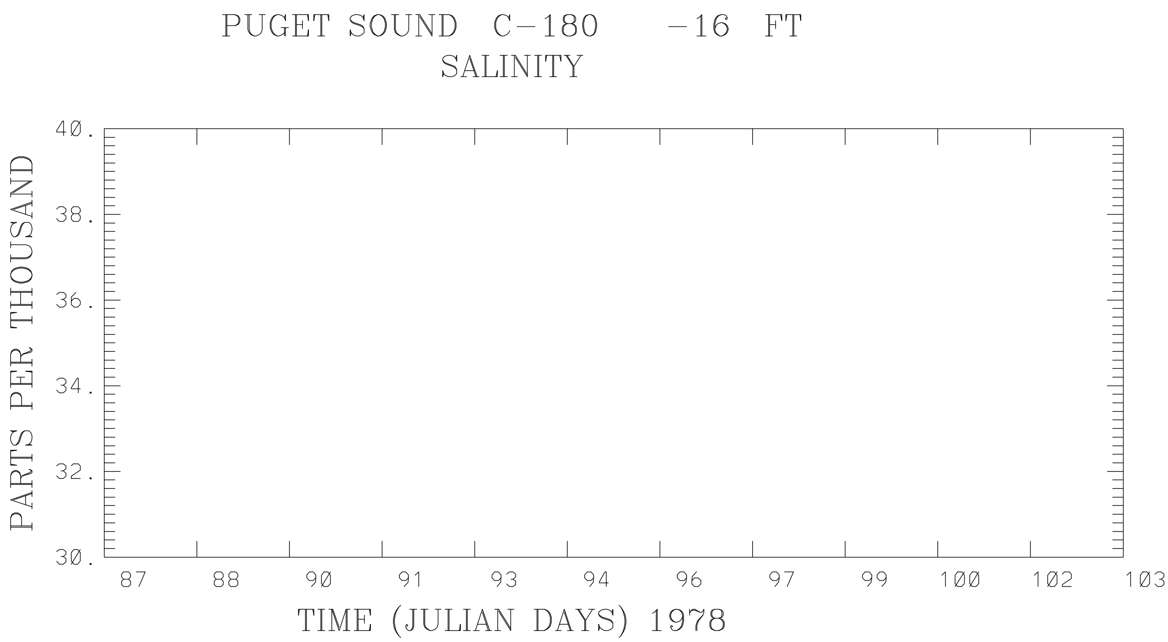


Figure 3.26. Station C-180 Puget Sound Salinity and Temperature at 16 ft below the surface in March 1978. Note from Table 3.6 no salinity data are available at this station.

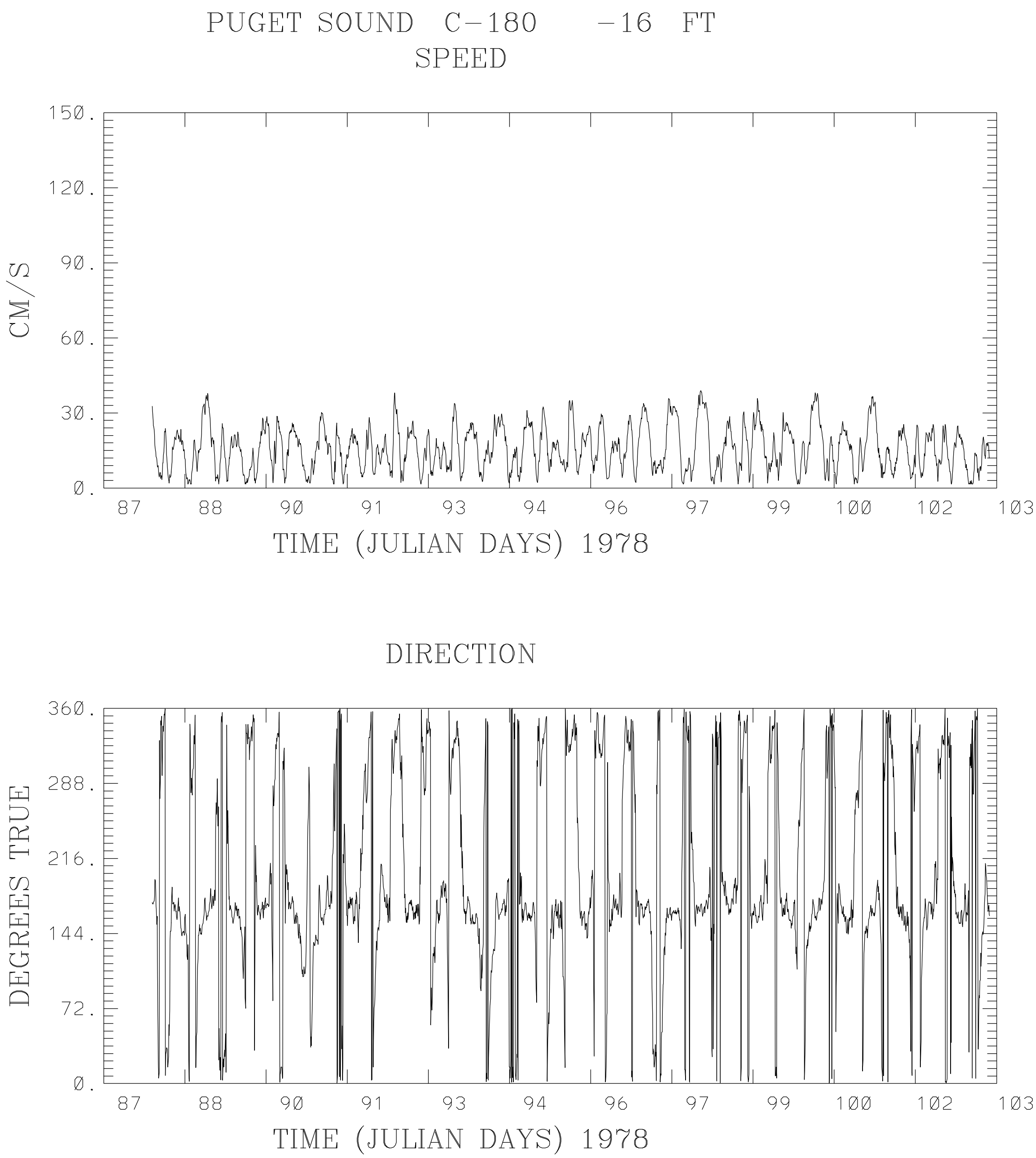


Figure 3.27. Station C-180 Puget Sound Current Speed and Direction at 16 ft below the surface in March 1978.

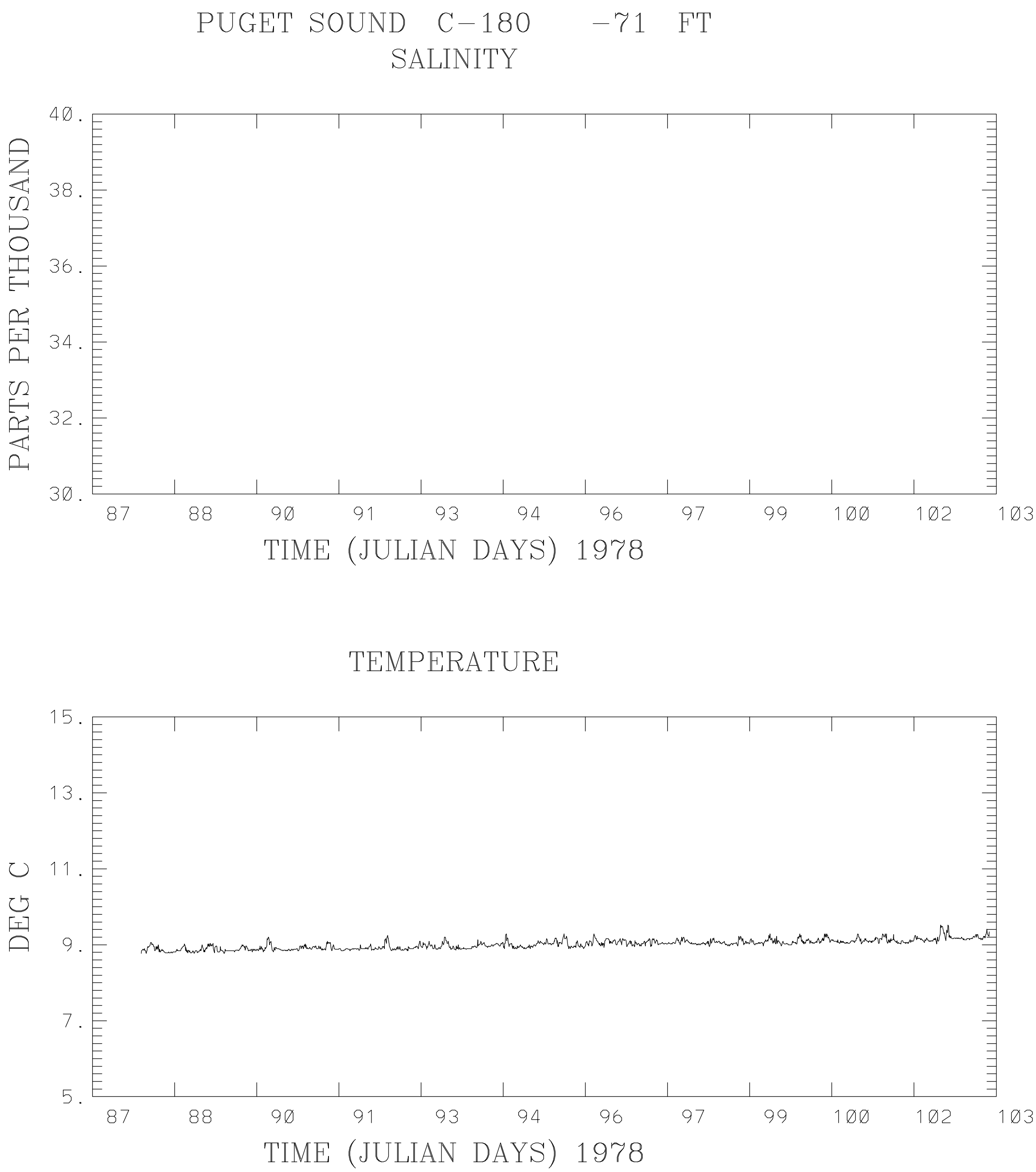


Figure 3.28. Station C-180 Puget Sound Salinity and Temperature at 71 ft below the surface in March 1978. Note from Table 3.6 no salinity data are available at this station.

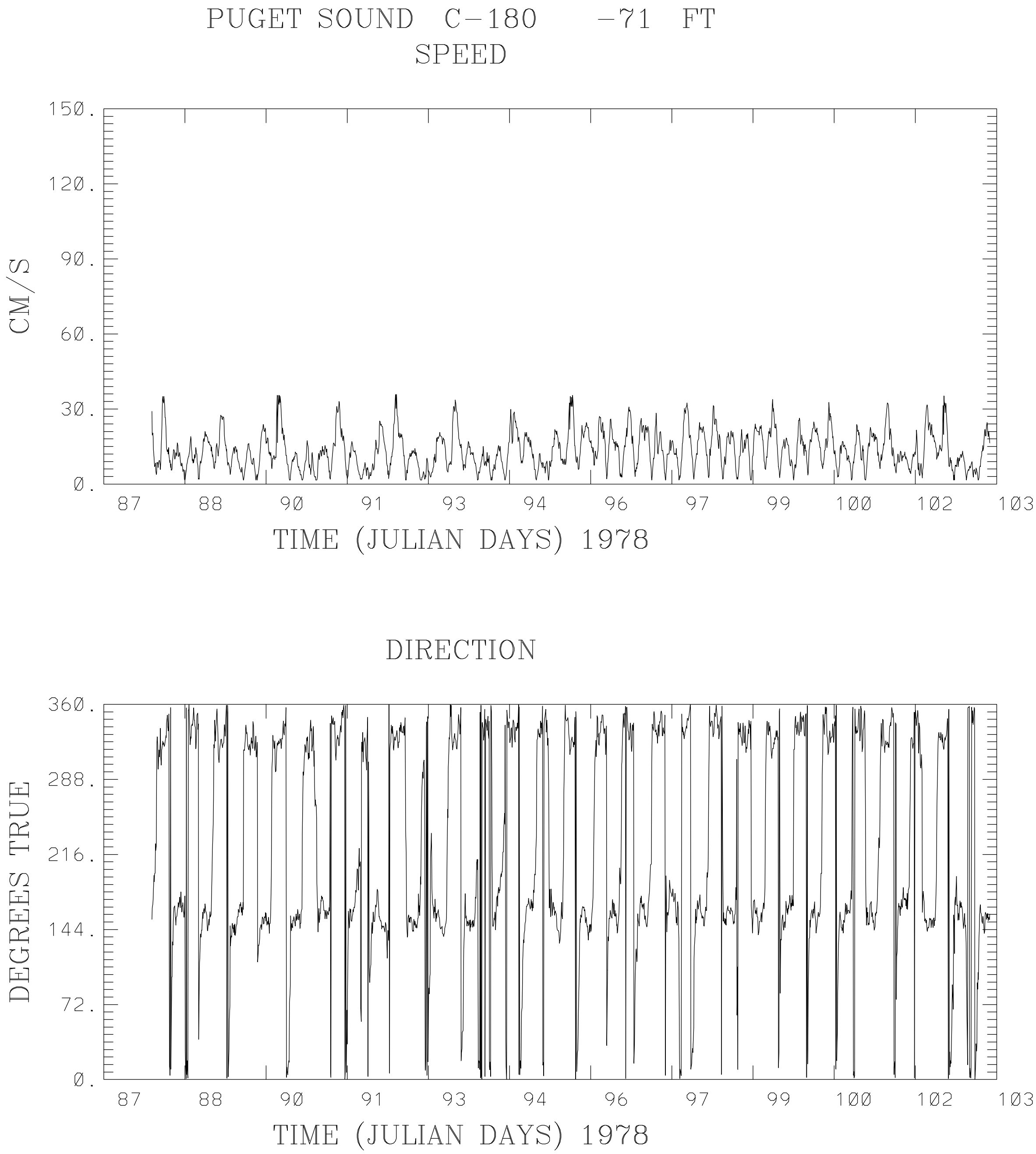


Figure 3.29. Station C-180 Puget Sound Current Speed and Direction at 71 ft below the surface in March 1978.

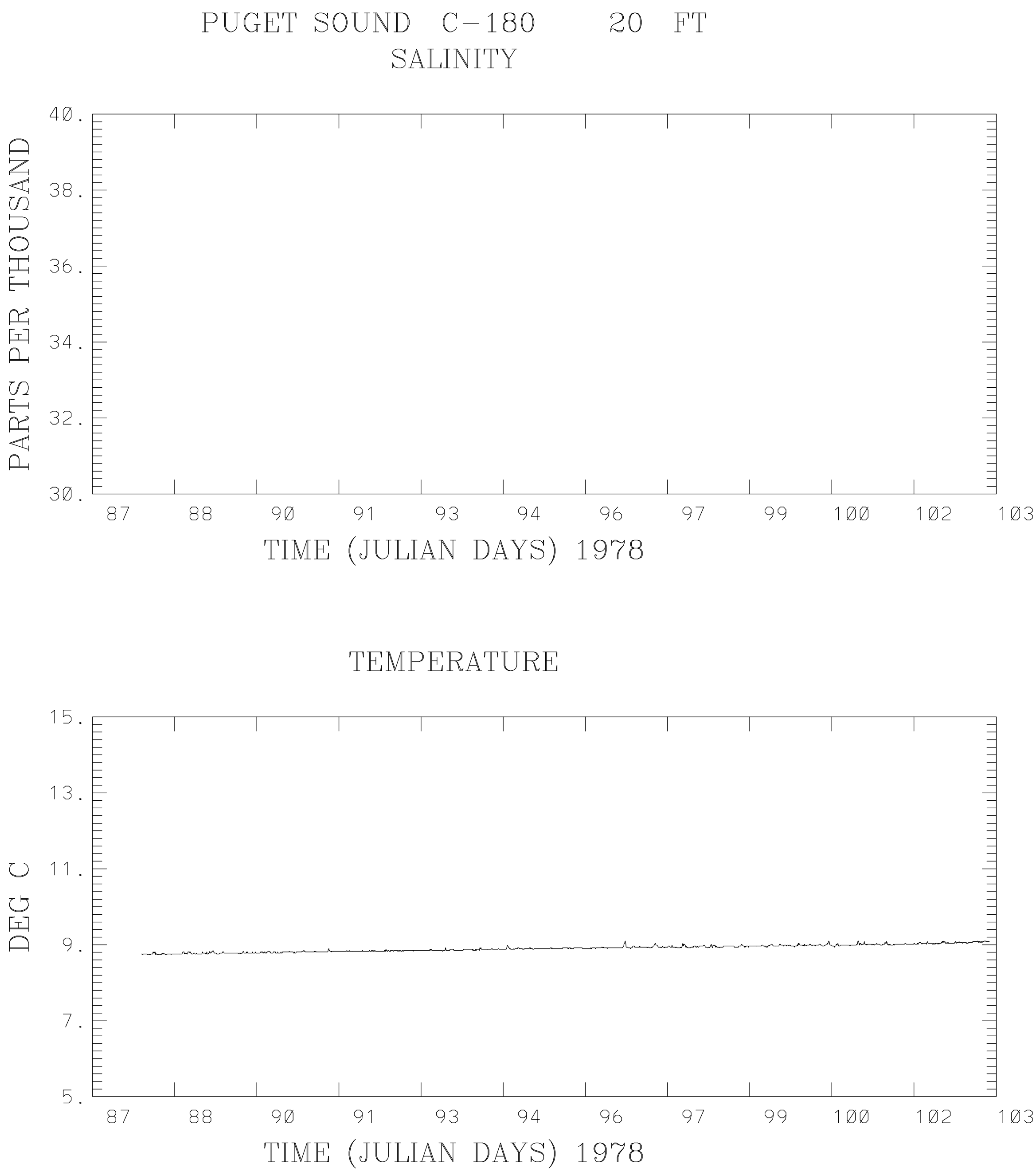


Figure 3.30. Station C-180 Puget Sound Salinity and Temperature at 20 ft above the bottom in March 1978. From Table 3.6 no salinity data are available at this station.

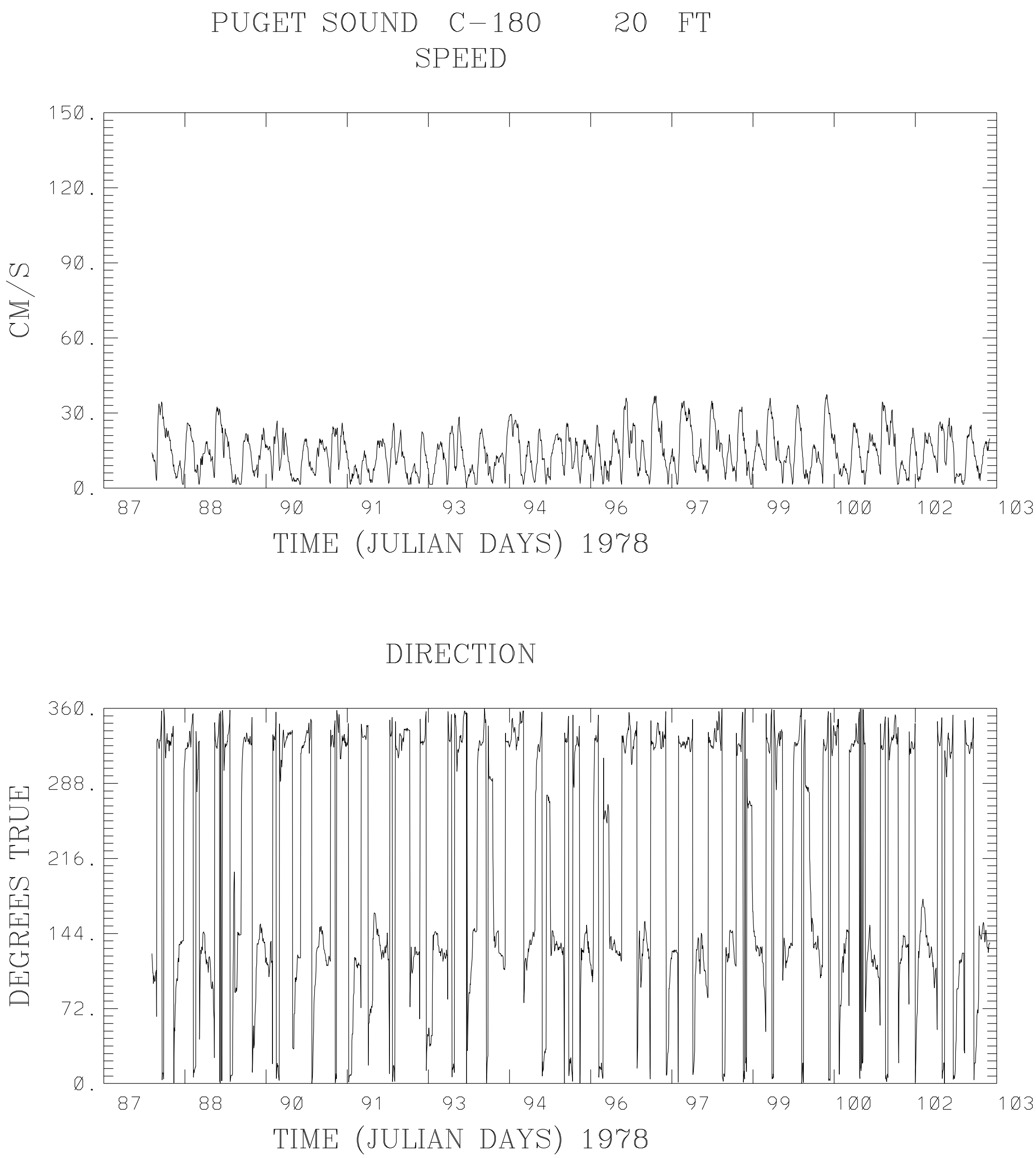


Figure 3.31. Station C-180 Puget Sound Current Speed and Direction at 20 ft above the bottom in March 1978.

4. YAQUINA RIVER

NOS performed a survey in 1982 to study the circulation in Yaquina River. The Aanderaa Model RCM-4 current meter recorded and measured current speed and direction and included temperature, conductivity and pressure sensors. Here, we summarize the recovered data and discuss related regional oceanographic characteristics.

Data Inventory and Summary

The datasets obtained from CO-OPS on compact disc are listed in Table 4.1 and constitute the recoverable data. It was necessary to carefully inventory these datasets and determine their data quality.

Table 4.1. Yaquina River Circulation Survey Raw Data Inventory.

Directory Name	Number of Files	Data Period	Data Description	Data Quality
YAQ1	22	1982	Aanderaa Current Meter	OK
YAQ2	4	1982	Aanderaa Current Meter	OK

CT/Current Data

The salinity and temperature and current data inventoried in Table 4.2 were distributed amongst two directories: Yaq1 and Yaq2. The data files in these directories (FILE1 through FILEn) were concatenated to create cumulative data files: such as file_yaq1 and file_yaq2. The data in each individual data file (FILE1 through FILEn) represent current and CT data at one specific station location over a given time period. It should be noted that since the focus was on data for model validation and harmonic analysis, only stations with record lengths of 15 days or greater were considered. In general, data quality was sufficient, such that no editing was performed.

Both datasets are described in Table 4.3 in terms of station location, measurement and station depths and measurement dates and durations. Note in these tables that the station depths are estimated from Nautical Chart 18581 18th Edition. Station locations are shown in Figure 4.1 for both datasets.

Table 4.2. Yaquina River Circulation Survey Processed Data File Inventory.

Data Type	Location	Filename
CT/Current Raw	~/yaquina/YAQ1/ ~/yaquina/YAQ2/	FILE1 – FILE22, FILE1 – FILE4
CT/Current Edited	~/yaquina/yaq1/ ~/yaquina/yaq2/	file_yaq1 file_yaq2
CT/Current Qc	~/qc/	file_yaq1.qc file_yaq2.qc

~ = /disks/NASUSER/philr/westcoast

Table 4.3. Yaquina River Datasets 1 and 2.

Station No.	Latitude (°N)	Longitude (°W)	M-Depth (ft)	S-Depth (ft)	Measurement Dates mm/dd/yr		Data Length Days	Data Quality STAD
C-47	44.630	124.050	5	16	11/15/82	11/30/82	15.06	
C-48	44.627	124.047	15	20	11/16/82	12/ 1/82	15.22	
C-49	44.621	124.027	15	25	11/16/82	12/ 1/82	15.17	
C-53	44.586	124.021	5	9	11/ 1/82	11/17/82	16.63	
C-55	44.573	123.974	5	9	10/29/82	11/17/82	18.84	
C-55	44.573	123.974	5	9	11/17/82	12/ 2/82	15.01	

Notes: M-Depth=measurement depth with respect to MLLS, where positive numbers are distance above the bottom and negative numbers are distance below the surface. S-Depth=station depth with respect to MLLW. Note x denotes bad data within the STAD station matrix where S=salinity, T=temperature, A=current speed, and D=current direction.

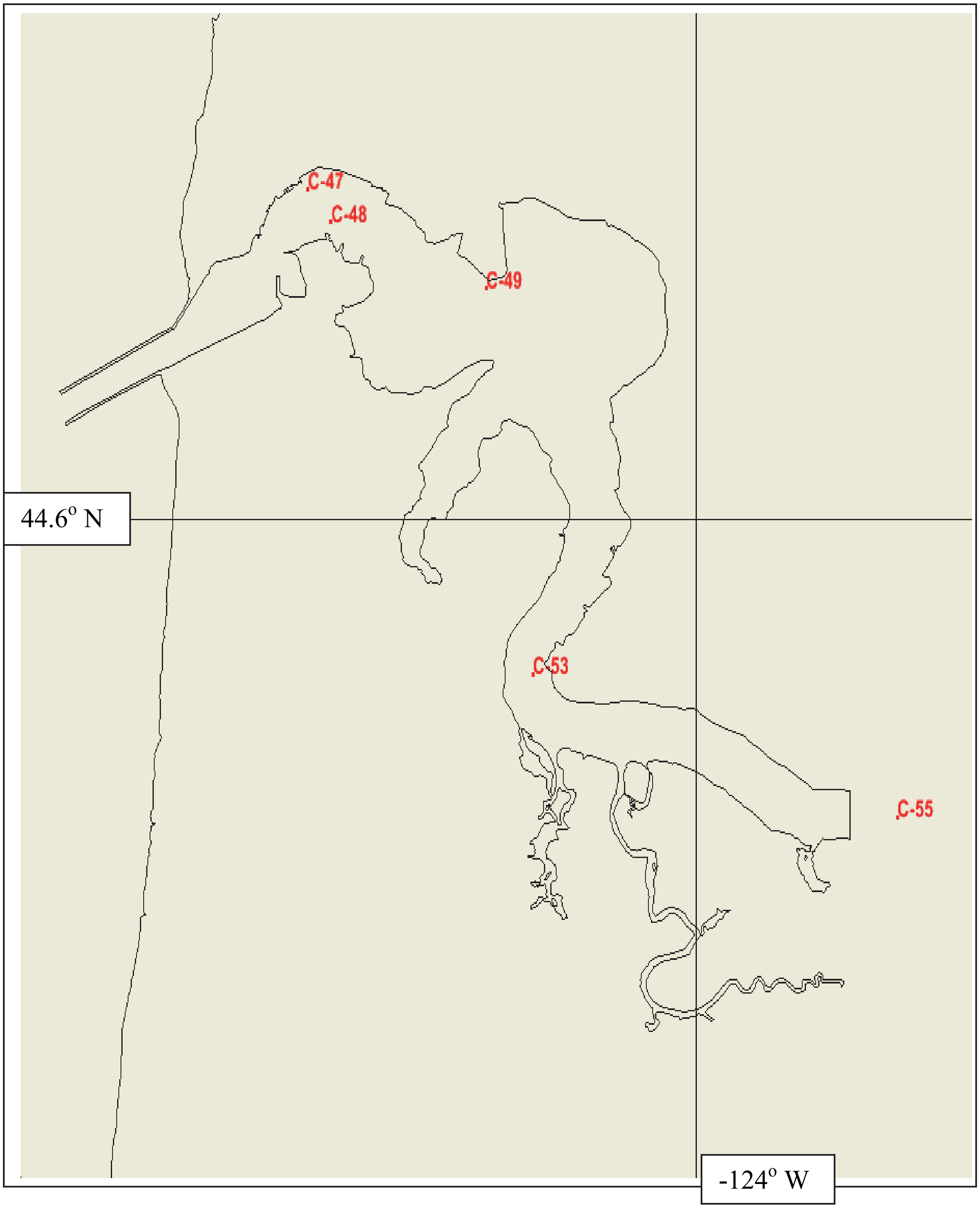


Figure 4.1. Station Locations for Yaquina River Datasets 1 and 2. Note C-55 is further to the east above C-53.

Regional Oceanographic Characteristics

From Wikipedia (http://en.wikipedia.org/wiki/Yaquina_River), we briefly review some of the major characteristics. The Yaquina River is approximately 50 miles long and lies on the Pacific coast of Oregon. It drains an area of the Central Oregon Coast Range west of the Willamette Valley near Newport. It rises in the valleys west of Corvallis and flows south, then generally west, in a highly serpentine course, past Toledo. It enters the Pacific in Yaquina Bay, a broad estuary at Newport.

Yaquina Bay and Harbor is one of the oldest navigation projects on the Oregon Coast. The Bay and Harbor include two jetties, numerous channels, turning and boat basins, and a breakwater. Yaquina Bay's north jetty was originally constructed to a length of 7,000 feet and then extended in 1966. The 8,600 foot south jetty was completed in 1896 and extended 1,800 feet in 1972.

Yaquina Bay has a 40 foot-deep and 400 foot-wide entrance channel. It has a 30 foot-deep, 300 foot-wide bay channel leading to a turning basin at Newport. There is also an 18 foot-deep, 200 foot-wide, 4.5 mile long channel from Newport to Yaquina. The Bay also has a 1,300 foot-long breakwater to protect the Newport South Beach Marina.

Coastal upwelling along the Eastern Pacific provides a major source of nutrients during the summer as described by Sigleo et al. (2005), with a focus on nitrate variations. Their analysis indicated that the variations in nitrate and water property variations at the Yaquina Bay entrance jetties were influenced by the estuarine outflow as well as by coastal upwelling.

Here we examine CT/Current time series in the Fall of 1982 at Station C-47 near the entrance of Yaquina Bay at 5 ft above the bottom. For salinity and temperature time series in Figure 4.2 there is some high frequency content, which may need filtering. In Figure 4.3 peak current speeds are less than 20 cm/s with some noise. At Station C-55 at the head of the Bay, salinity and temperature at 5 ft above the bottom are shown in Figure 4.4. One notes the large influence of the Yaquina River on the salinity signal and the decrease in temperature on the order of 4^oC over this 20 day period. Current speed and direction is shown in Figure 4.5, with significant differences in ebb and flood current speeds between Julian Days 307 and 315.

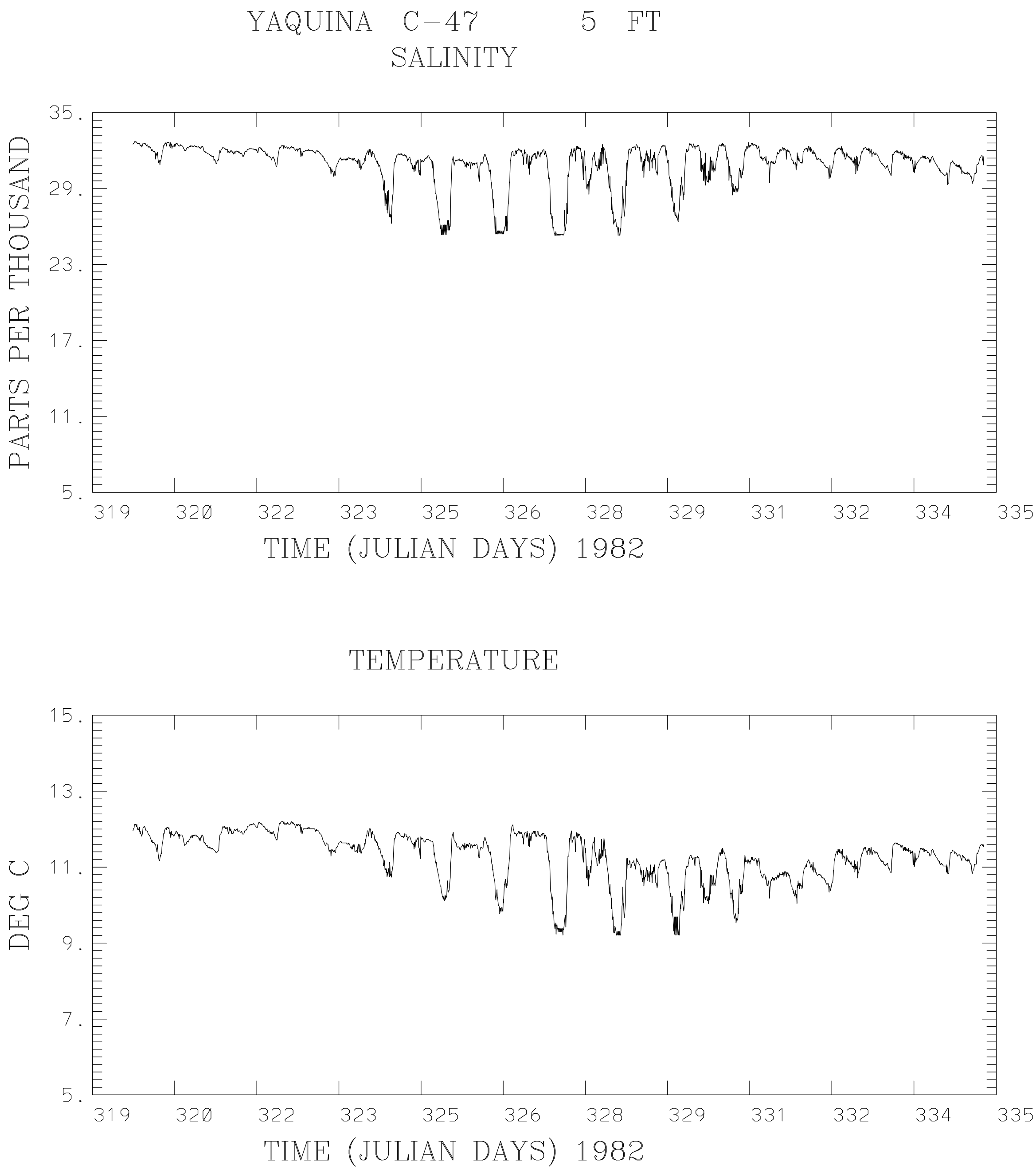


Figure 4.2. Station C-47 Yaquina River Salinity and Temperature at 5 ft above the bottom in November 1982.

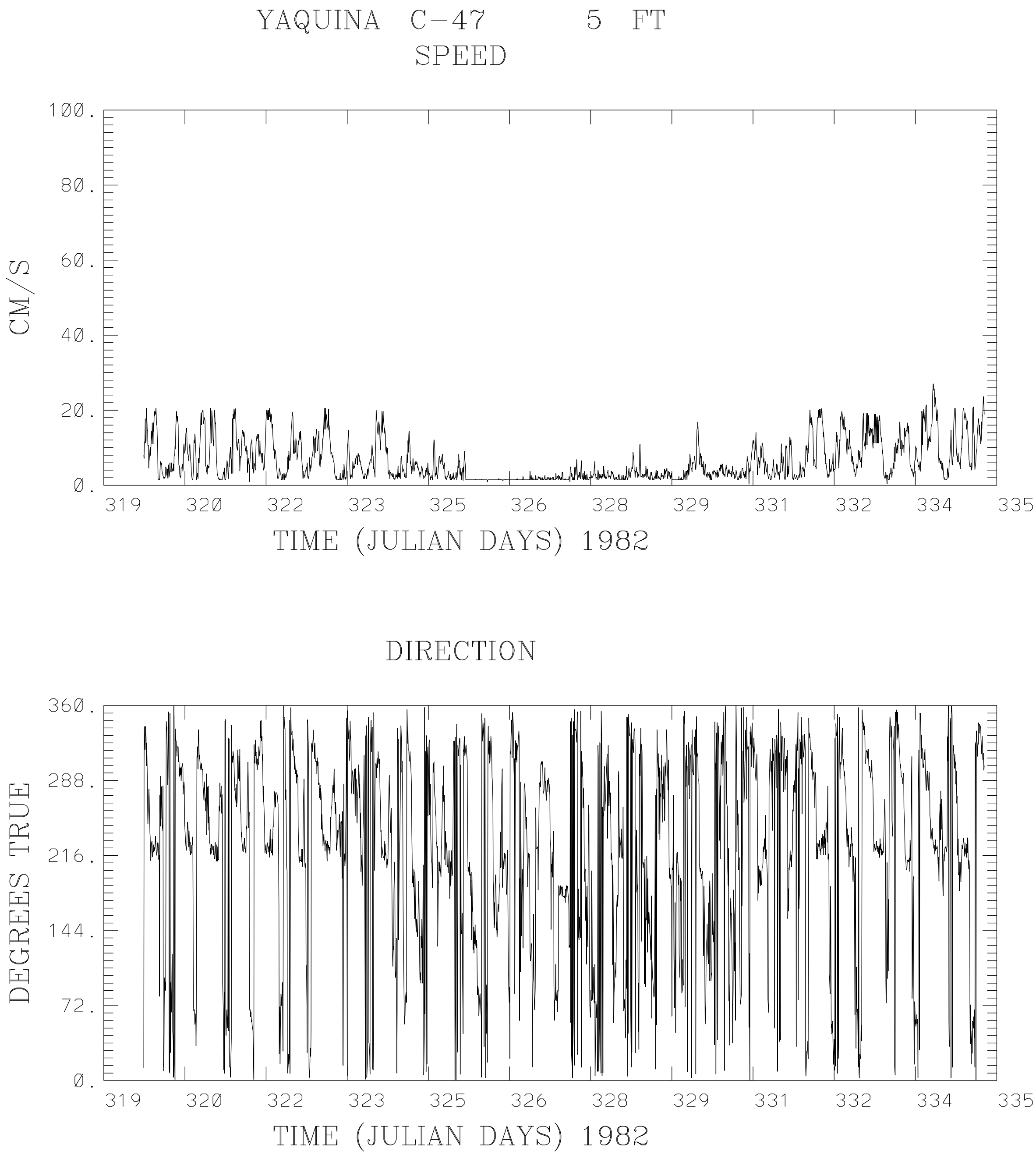


Figure 4.3. Station C-47 Yaquina River Current Speed and Direction at 5 ft above the bottom in November 1982.

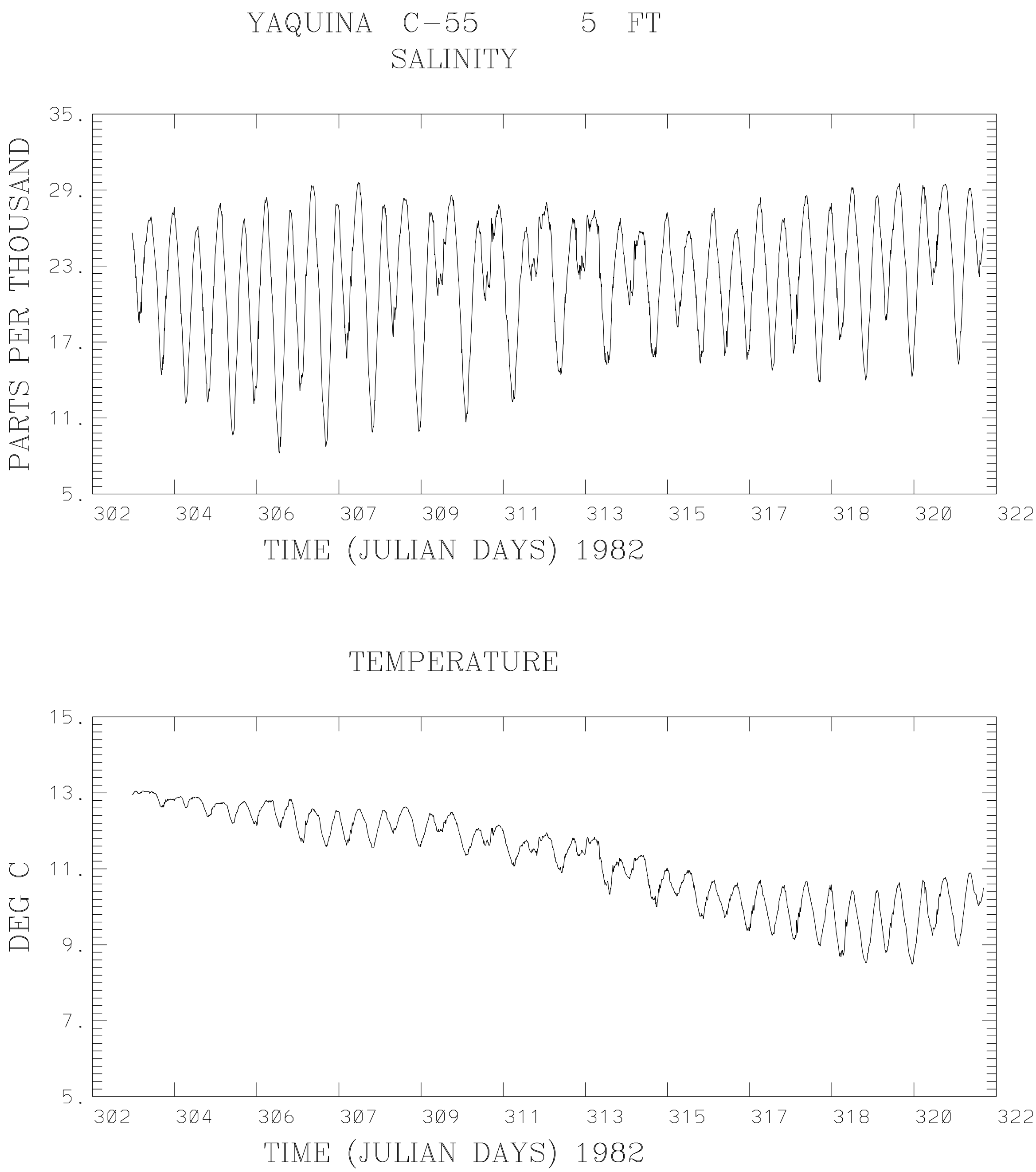


Figure 4.4. Station C-55 Yaquina River Salinity and Temperature at 5 ft above the bottom in November 1982.

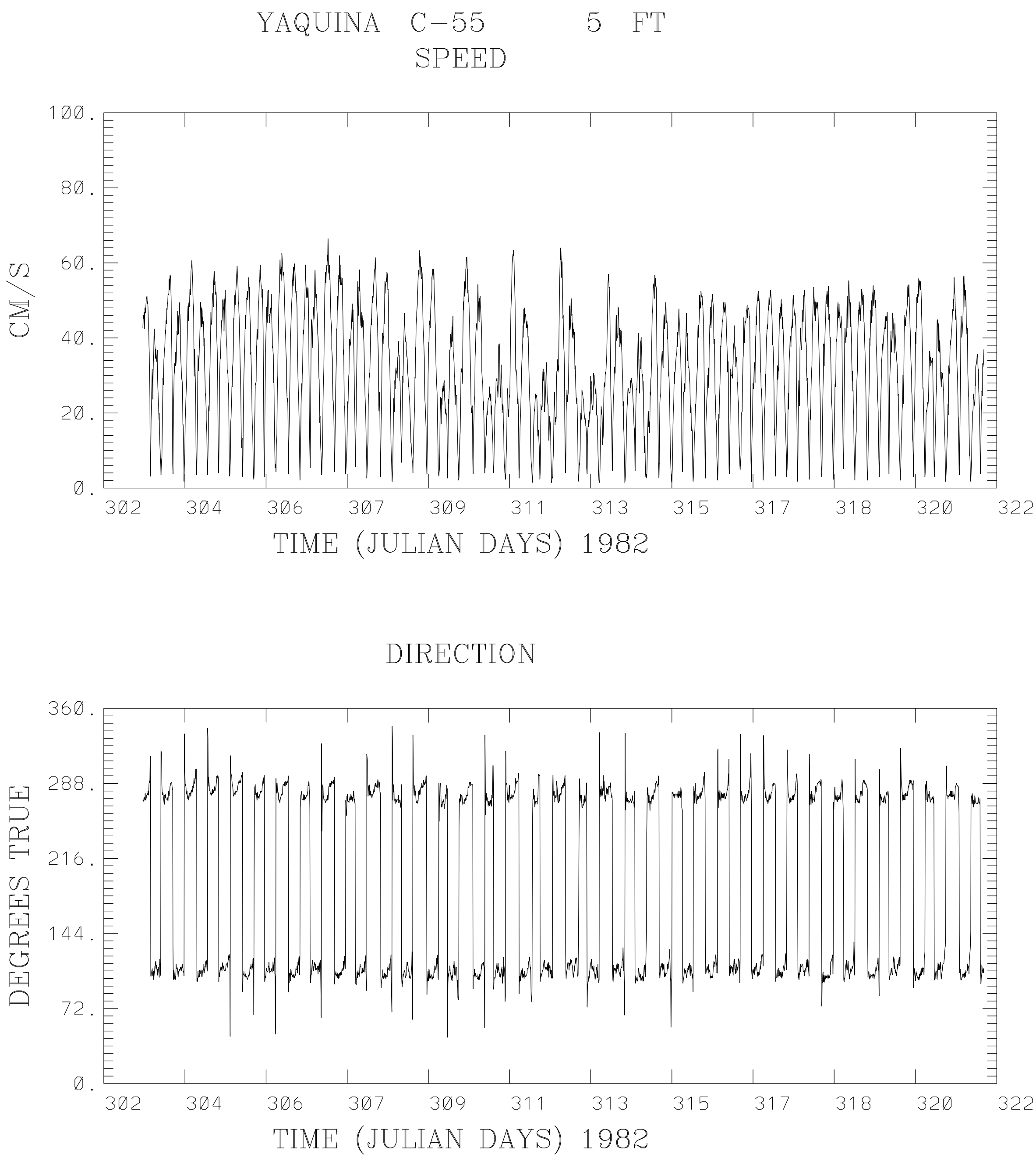


Figure 4.5. Station C-55 Yaquina River Current Speed and Direction at 5 ft above the bottom in November 1982.

5. WILLAPA BAY/ GRAYS HARBOR

NOS performed a short survey in 1982 to study the circulation in Willapa Bay and Grays Harbor. The Aanderaa Model RCM-4 current meter recorded and measured current speed and direction and included temperature, conductivity and pressure sensors. Here, we summarize the recovered data and discuss related regional oceanographic characteristics.

Data Inventory and Summary

The datasets obtained from CO-OPS on compact disc are listed in Table 5.1 and constitute the recoverable data. It was necessary to carefully inventory these datasets and determine their data quality. Note that neither meteorological data (wind speed and direction, and sea level atmospheric pressure) nor CTD profile data were available.

Table 5.1. Willapa Bay/Grays Harbor Circulation Survey Raw Data Inventory.

Directory Name	Number of Files	Data Period	Data Description	Data Quality
WILGRA	43	1982	Aanderaa Current Meter	OK

CT/Current Data

The salinity and temperature and current data inventoried in Table 5.2 were distributed in one directory: willapa. These data files (FILE1 through FILEn) were concatenated to create a cumulative data file: file_willapa. The data in each individual data file (FILE1 through FILEn) represent current and CT data at one specific station location over a given time period. It should be noted that since the focus was on data for model validation and harmonic analysis, only stations with record lengths of 15 days or greater were considered. In general, data quality was sufficient, such that no editing was performed.

Table 5.2. Willapa Bay/Grays Harbor Circulation Survey Processed Data File Inventory.

Data Type	Location	Filename
CT/Current Raw	~/willapa/WILGRA/	FILE1 – FILE43
CT/Current Edited	~/willapa/wilgra/	file_willapa
CT/Current Qc	~/qc/	file_will.qc

~ = /disks/NASUSER/philr/westcoast

Dataset 1 is described in Table 5.3, in terms of station location, measurement and station depths and measurement dates and durations. Note that in the table station depths are estimated from Nautical Chart 18504 66th Edition for Grays Harbor and Nautical Chart 18502 87th Edition for Willapa Bay. Note Station C-19 is located on land according to the nautical chart indicating an error in the station location. Station locations are shown in Figure 5.1.

Table 5.3. Willapa Bay/Grays Harbor Dataset 1.

Station No.	Latitude (°N)	Longitude (°W)	M-Depth (ft)	S-Depth (ft)	Measurement Dates mm/dd/yr		Data Length Days	Data Quality STAD
C-17	46.974	123.804	14	25	5/24/82	6/ 9/82	15.74	
C-17	46.974	123.804	5	25	5/24/82	6/ 9/82	15.94	
C-28	46.488	123.962	20	30	5/26/82	6/14/82	19.06	
C-27	46.583	123.966	5	41	5/30/82	6/14/82	15.40	
C-22	46.702	123.891	5	21	5/28/82	6/14/82	16.93	
C-2	46.912	124.149	15	38	6/ 1/82	6/18/82	16.89	
C-2	46.912	124.149	5	38	6/ 1/82	6/18/82	16.88	
C-17	46.974	123.804	15	25	6/ 9/82	6/25/82	16.04	
C-6	46.949	124.096	15	24	6/18/82	7/ 7/82	19.01	
C-19	46.952	123.740	5	n/a	6/30/82	7/16/82	16.27	
C-16	46.960	123.845	20	22	7/ 1/82	7/19/82	18.00	x
C-16	46.960	123.845	5	22	7/ 1/82	7/19/82	18.02	x
C-13	46.946	123.994	15	22	7/ 1/82	7/20/82	18.98	
C-13	46.946	123.994	5	22	7/ 1/82	7/20/82	19.01	x
C-17	46.974	123.804	15	25	6/25/82	7/21/82	26.01	
C-17	46.974	123.804	5	25	6/25/82	7/21/82	25.97	
C-10	46.924	124.054	5	38	7/ 1/82	7/22/82	20.86	

Notes: M-Depth=measurement depth with respect to MLLW, where positive numbers are distance above the bottom and negative numbers are distance below the surface. S-Depth=station depth with respect to MLLW. Note x denotes bad data within the STAD station matrix where S=salinity, T=temperature, A=current speed, and D=current direction.

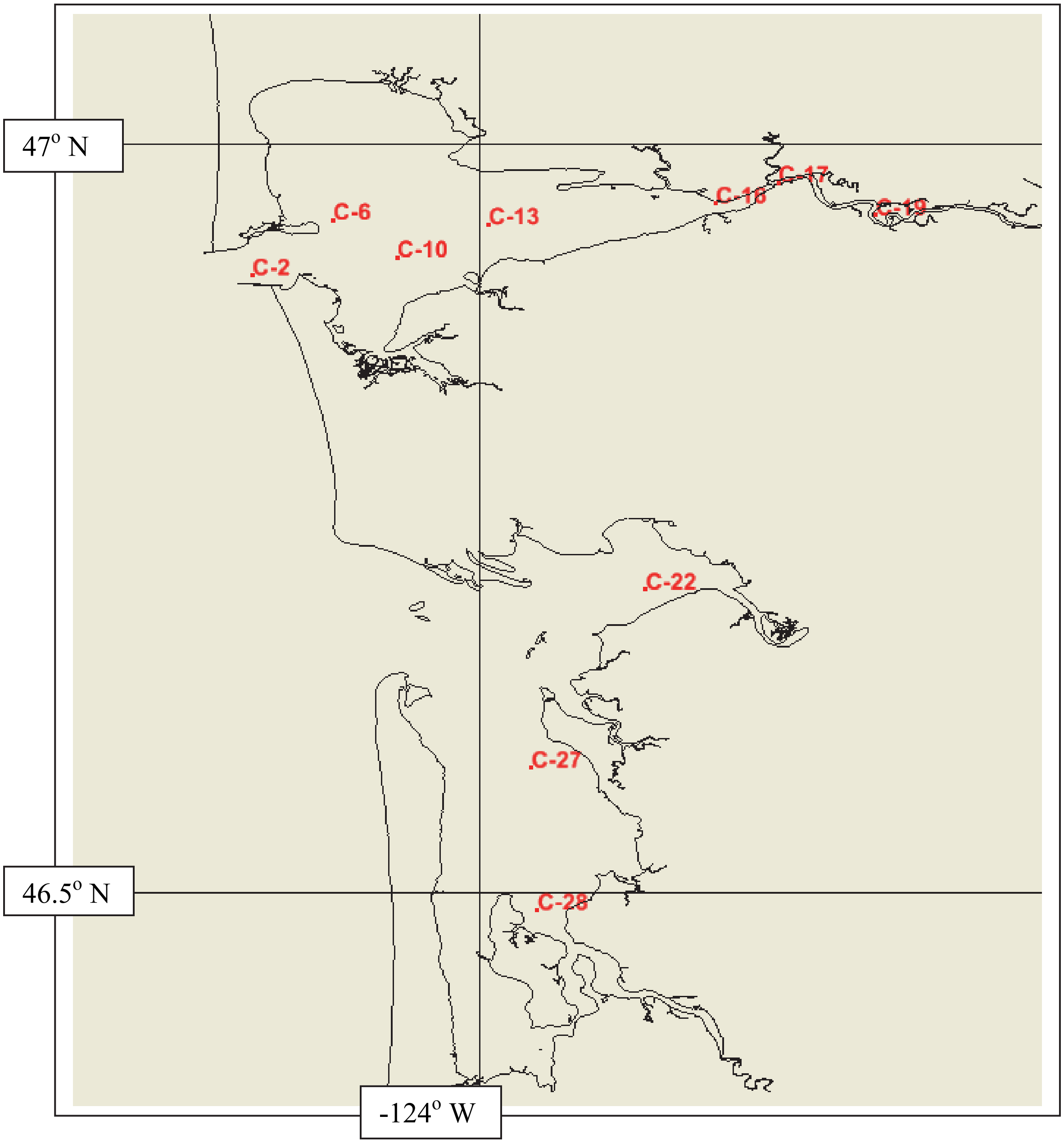


Figure 5.1. Station Locations for Willapa Bay/Grays Harbor Dataset 1. Note Grays Harbor is the northern water body.

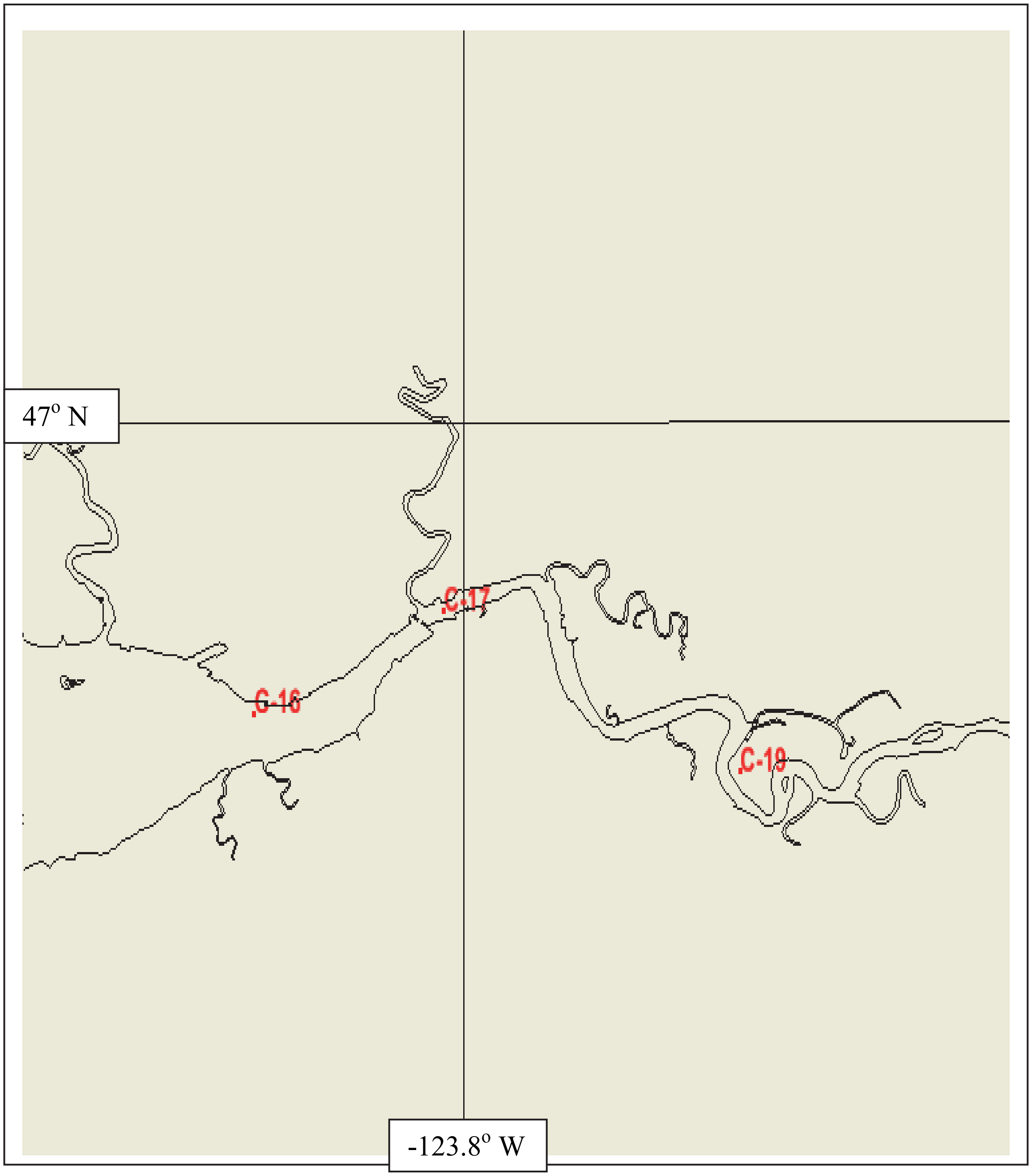


Figure 5.2. Station Locations for Upper Grays Harbor in the Chehalis River.

Regional Oceanographic Characteristics

Here we first review the overall characteristics of Willapa Bay as described on Wikipedia (http://en.wikpeida.org/wiki/Willapa_Bay). The Bay is located on the southwest Pacific Coast of Washington. With over 260 square miles of water surface, it is the second largest estuary on the Pacific Coast. The Bay is fairly shallow with more than half of its surface area lying in the intertidal zone. Half of the volume of water inside the Bay enters and leaves with every tide. The North River, Willapa River, and Naselle River provide most of the freshwater input. Other rivers that empty into Willapa Bay include the Bone River, Niawiakum River, Palix River, and the Bear River. The inlet of Willapa Bay is subjected to high waves, strong currents, and large variations in water elevation. The bathymetry at the entrance is complex and continually changing.

Banas and Hickey (2005) have studied Willapa Bay to examine transport pathways and residence time. They note that except at the highest winter storm river flows, river and ocean density driven exchanges are discernable but secondary to tidal stirring. Willapa Bay's morphology is a moving target, since channels can migrate up to 100m in a single year.

Grays Harbor is located to the north of Willapa Bay. From Wikipedia (http://en.wikpeida.org/wiki/Grays_Harbor), the bay is 17 miles long and 12 miles across with the Chehalis river flowing into it eastern end at Aberdeen, WA. A pair of low elevation peninsulas separate it from the Pacific Ocean, except for an opening about 2 miles in width, which is subjected to large waves. The US Army Corps of Engineers has built and maintained two rubble-mound jetties, a deep-draft navigation channel, and other navigational features in Grays Harbor. The North Jetty functions to block southward transport of sediment and to protect and maintain the entrance navigation channel. However the system is very complex and there is significant wave-current interaction which provides for severe sediment transport issues.

The oceanography of these two estuaries has been described by Hickey and Banas (2003) and suggests the major influence of the California Current System and seasonal fluctuations of upwelling-downwelling. They note that unlike East Coast estuaries, these estuaries may be considered as extensions of the coastal ocean during the summer when river outflow is low and flushing by the coastal ocean is high.

Here we examine CT/Current time series in May 1982 at Station C-17 in Grays Harbor for salinity and temperature time series at 14 ft and 5 ft above the bottom, shown in Figures 5.3 and 5.5. Note the large influence on the salinity signal of the river inflow. Current speed and direction at the corresponding depths are shown in Figures 5.4 and 5.6. Current speed and direction change significantly with depth.

CT/Current time series in May 1982 at Station C-28 in Willapa Bay are shown at 20 ft above the bottom in Figure 5.7 for salinity and temperature. Observe the indication of the horizontal advection of a large salinity gradient. In Figure 5.8 for current speed and direction, peak current speeds are approximately 75 cm/s with directions exhibiting a rectilinear flow.

In Figures 5.9 and 5.11, we present the salinity and temperature measured time series at Station C-2 at the entrance to Grays Harbor at 15 ft and 5 ft above the bottom. We note the signals are uniform over this depth range. Current speed and directions are shown at the corresponding depths in Figures 5.10 and 5.12, with current speed decreasing with depth and current direction being relatively uniform.

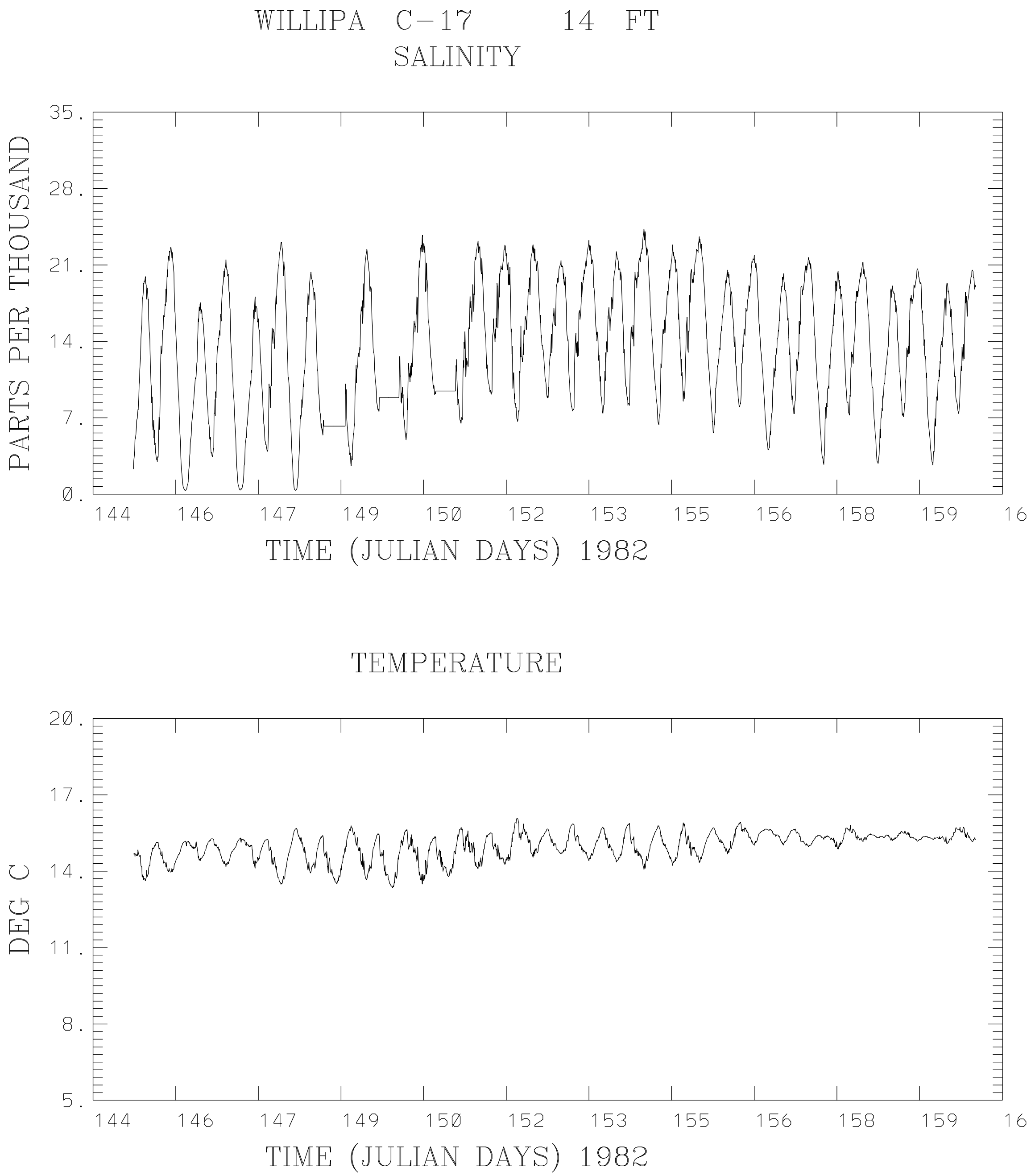


Figure 5.3. Station C-17 Grays Harbor Salinity and Temperature at 14 ft above the bottom in May 1982.

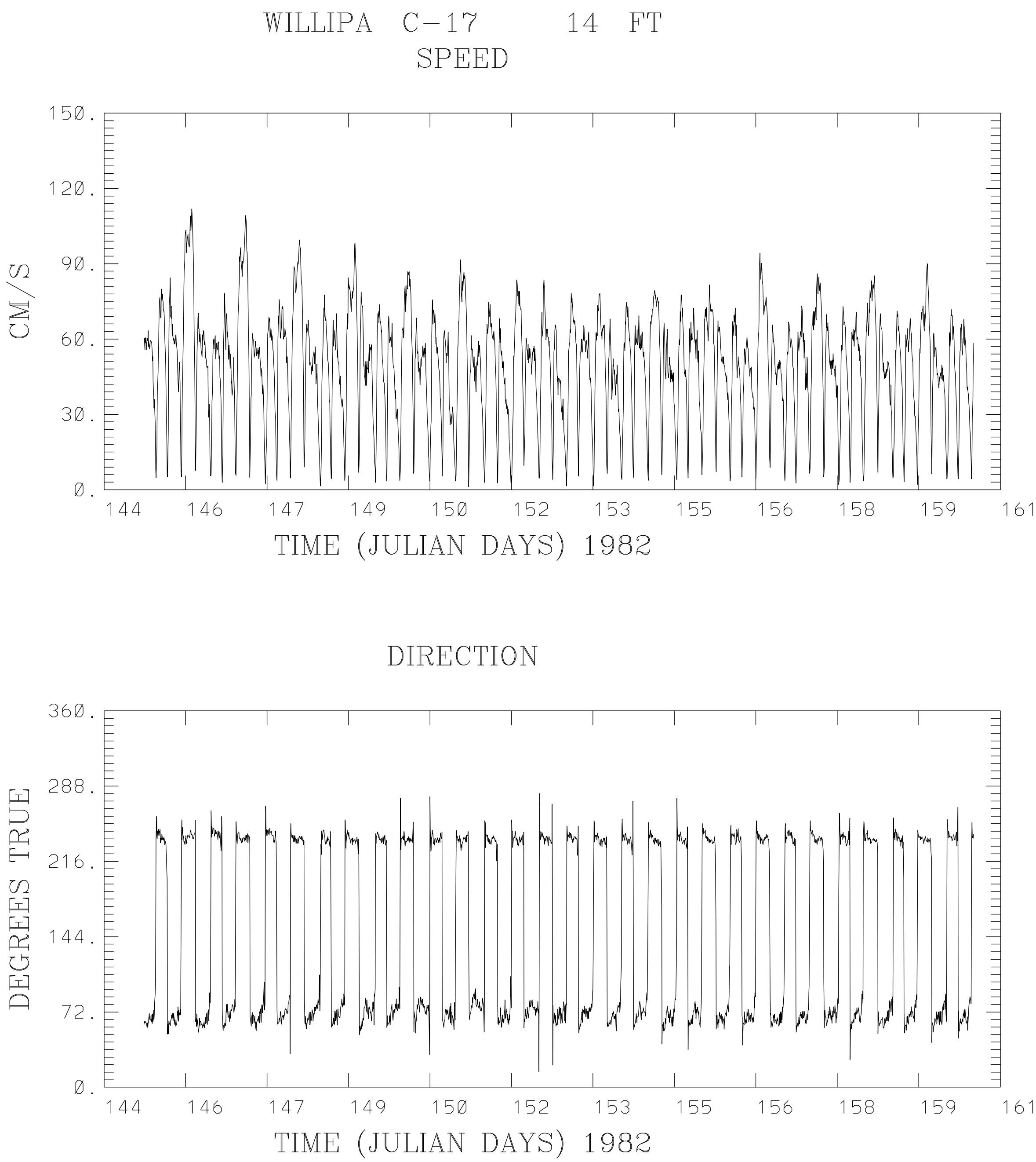
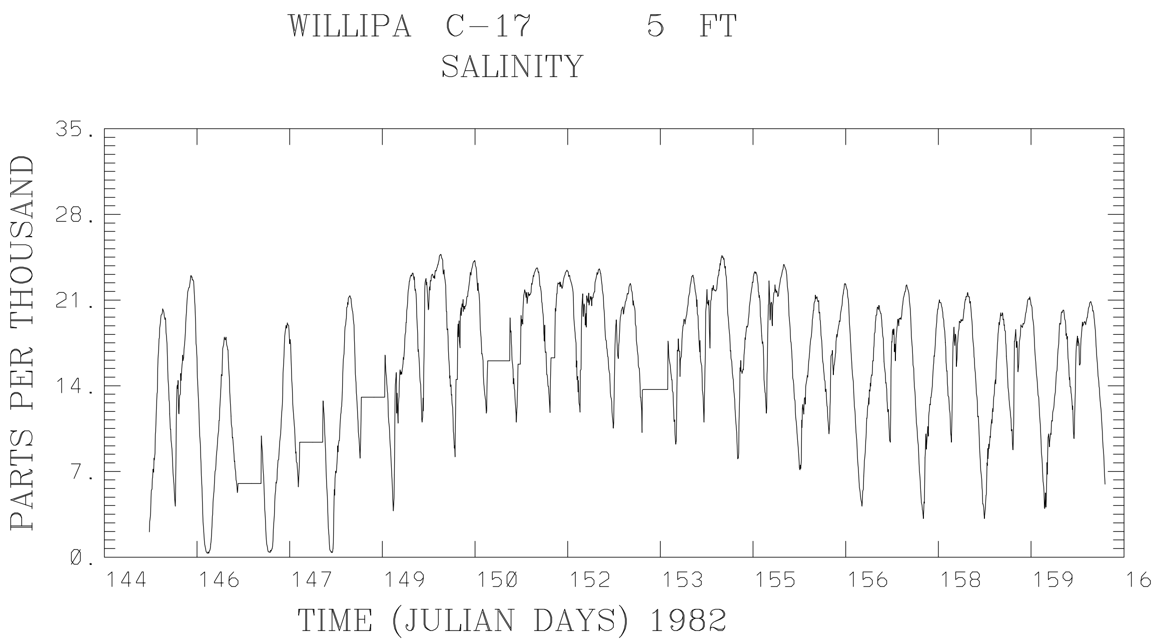


Figure 5.4. Station C-17 Grays Harbor Current Speed and Direction at 14 ft above the bottom in May 1982.



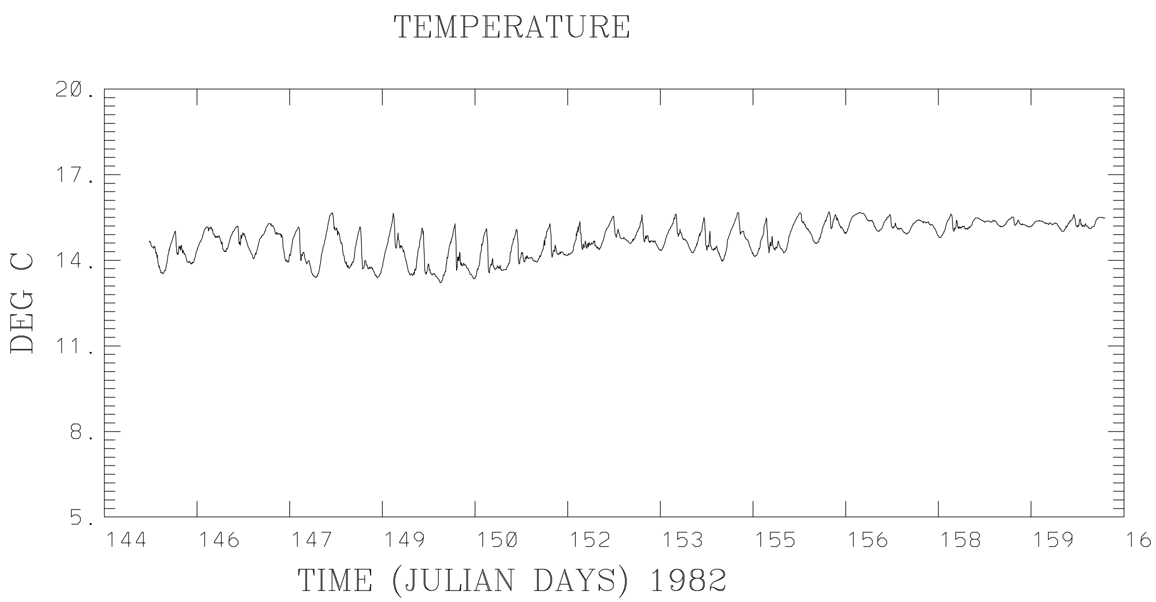


Figure 5.5. Station C-17 Willapa Bay Salinity and Temperature at 5 ft above the bottom in May 1982.

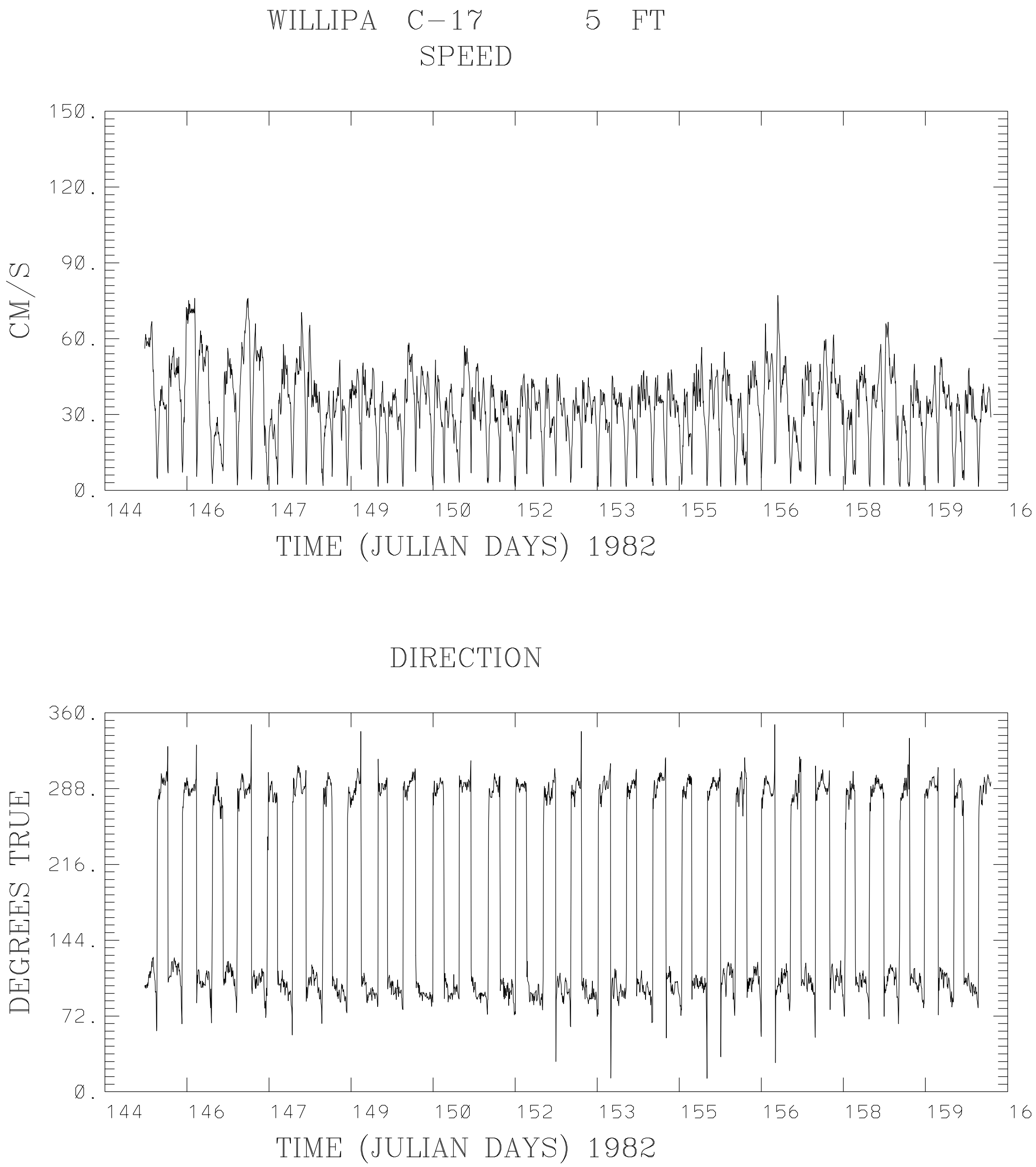


Figure 5.6. Station C-17 Willapa Bay Current Speed and Direction at 5 ft above the bottom in May 1982.

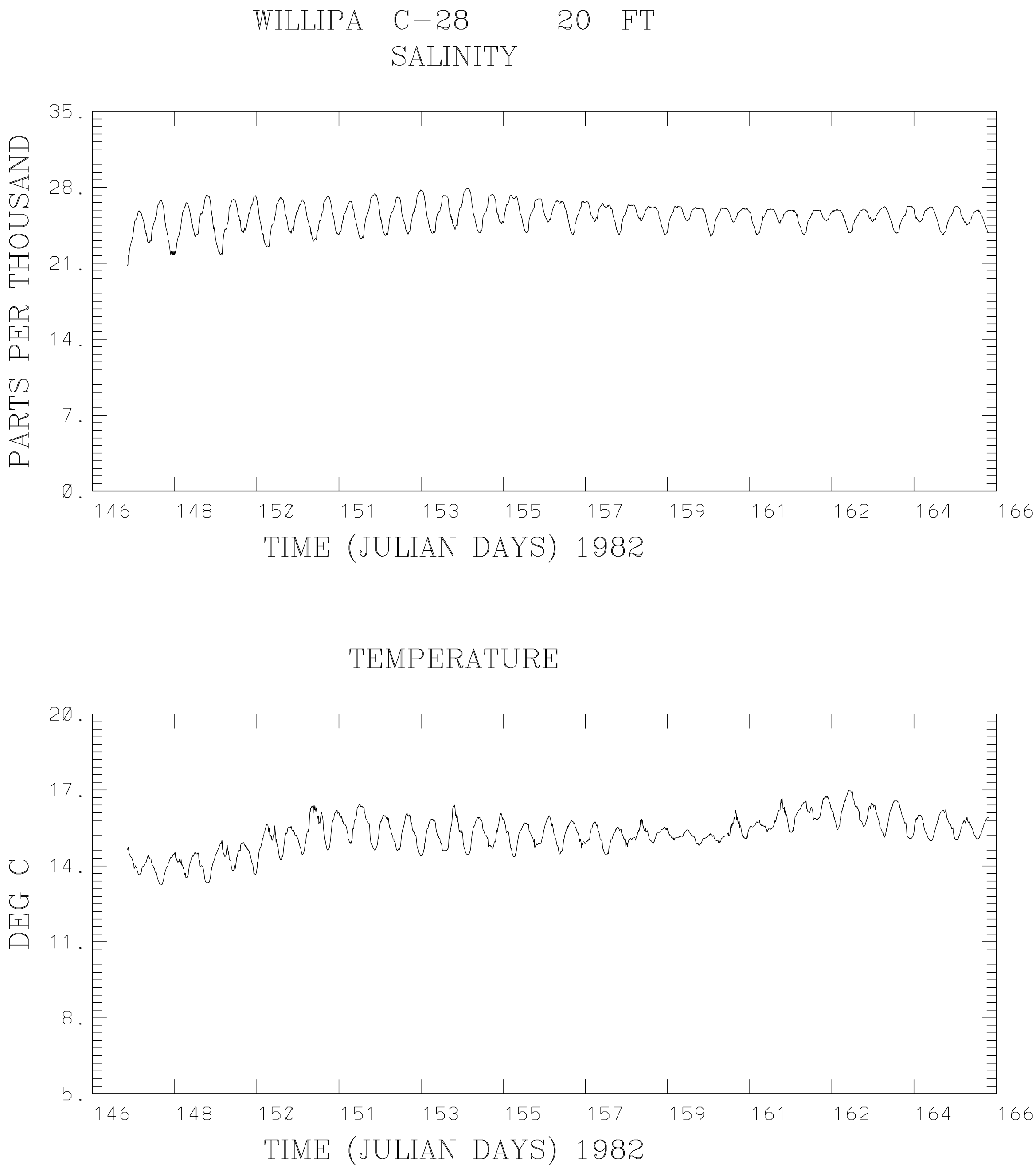


Figure 5.7. Station C-28 Willapa Bay Salinity and Temperature at 20 ft above the bottom in May 1982.

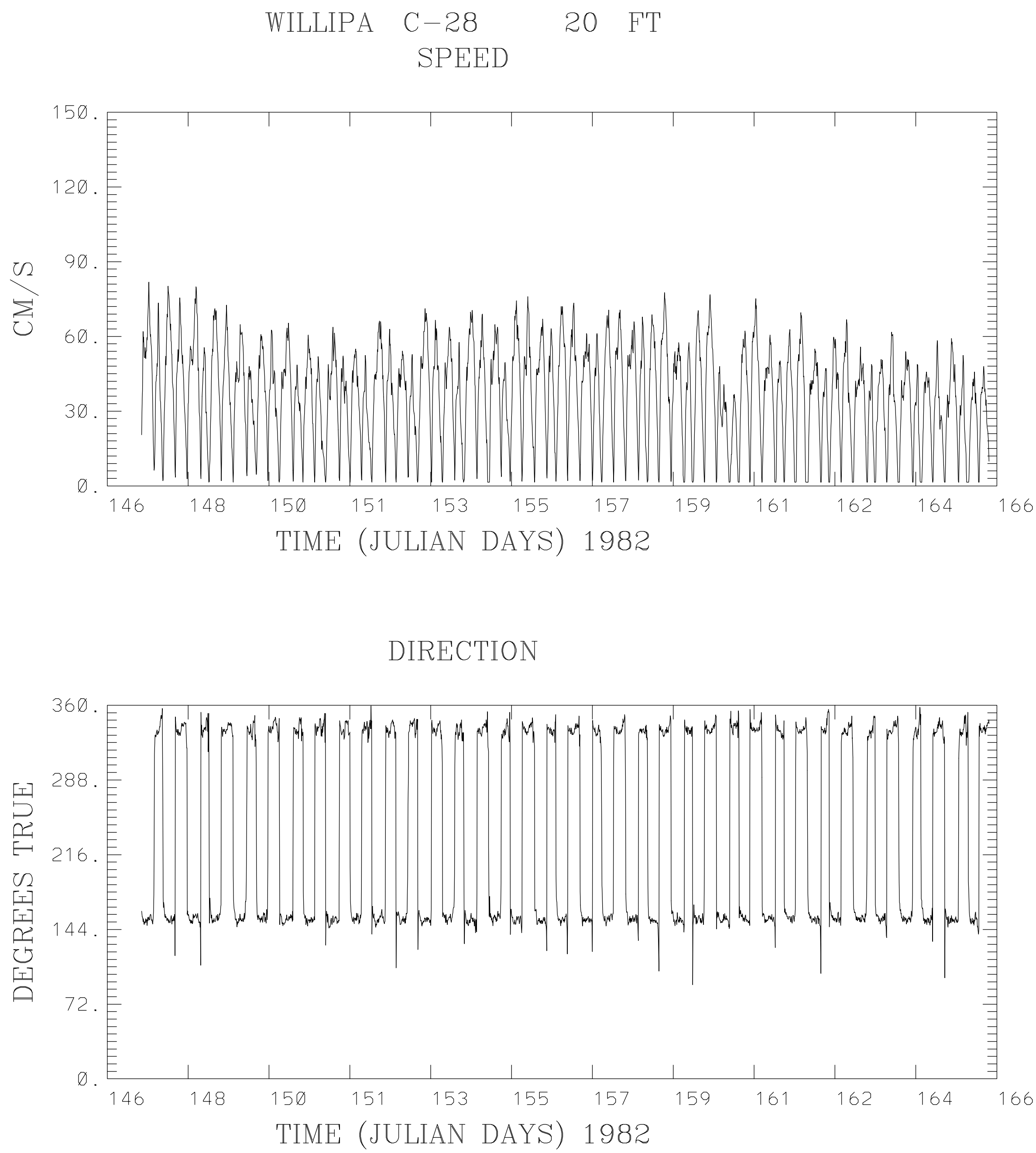


Figure 5.8. Station C-28 Willapa Bay Current Speed and Direction at 20 ft above the bottom in May 1982.

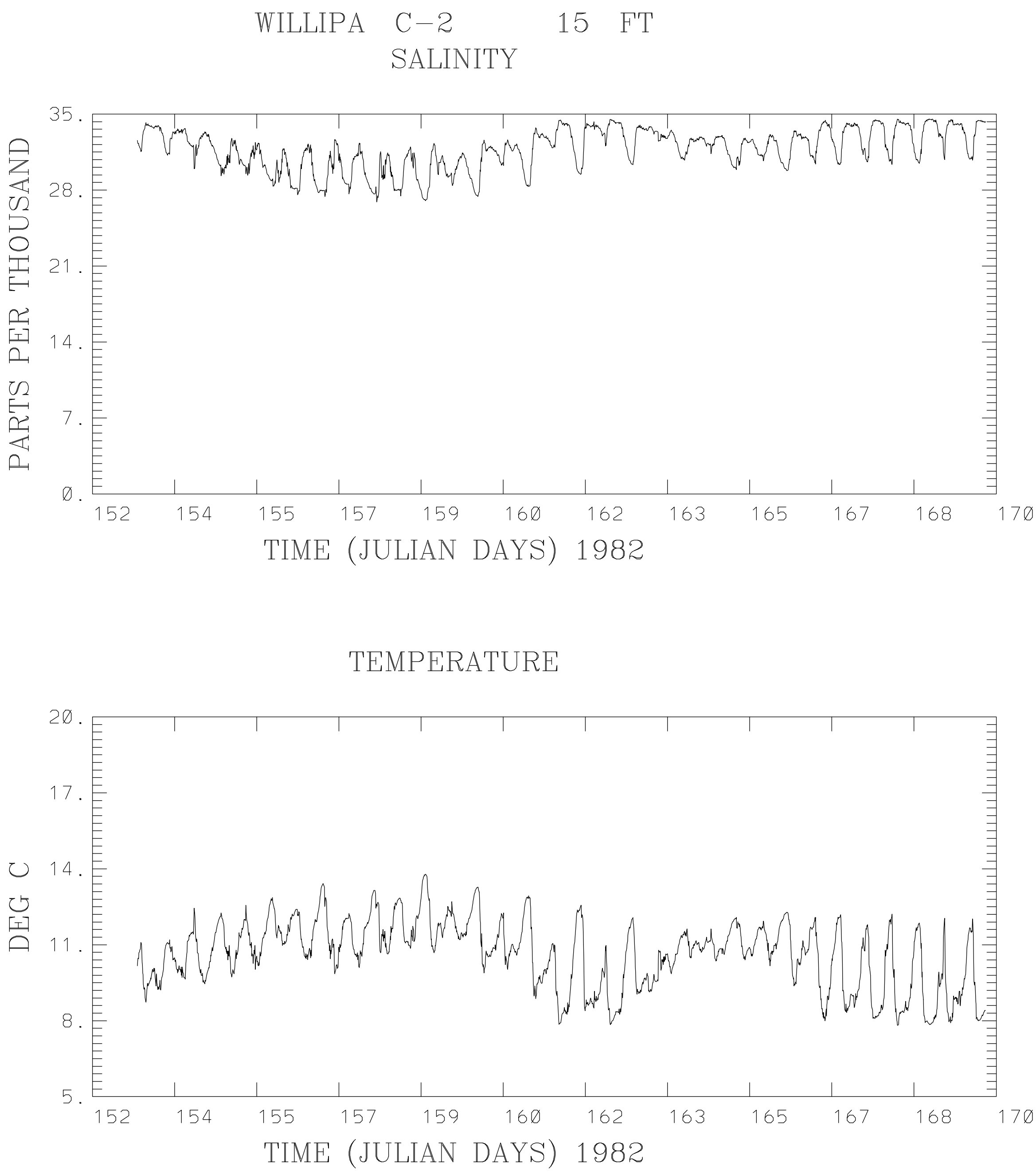


Figure 5.9. Station C-2 Willapa Bay Salinity and Temperature at 15 ft above the bottom in June 1982.

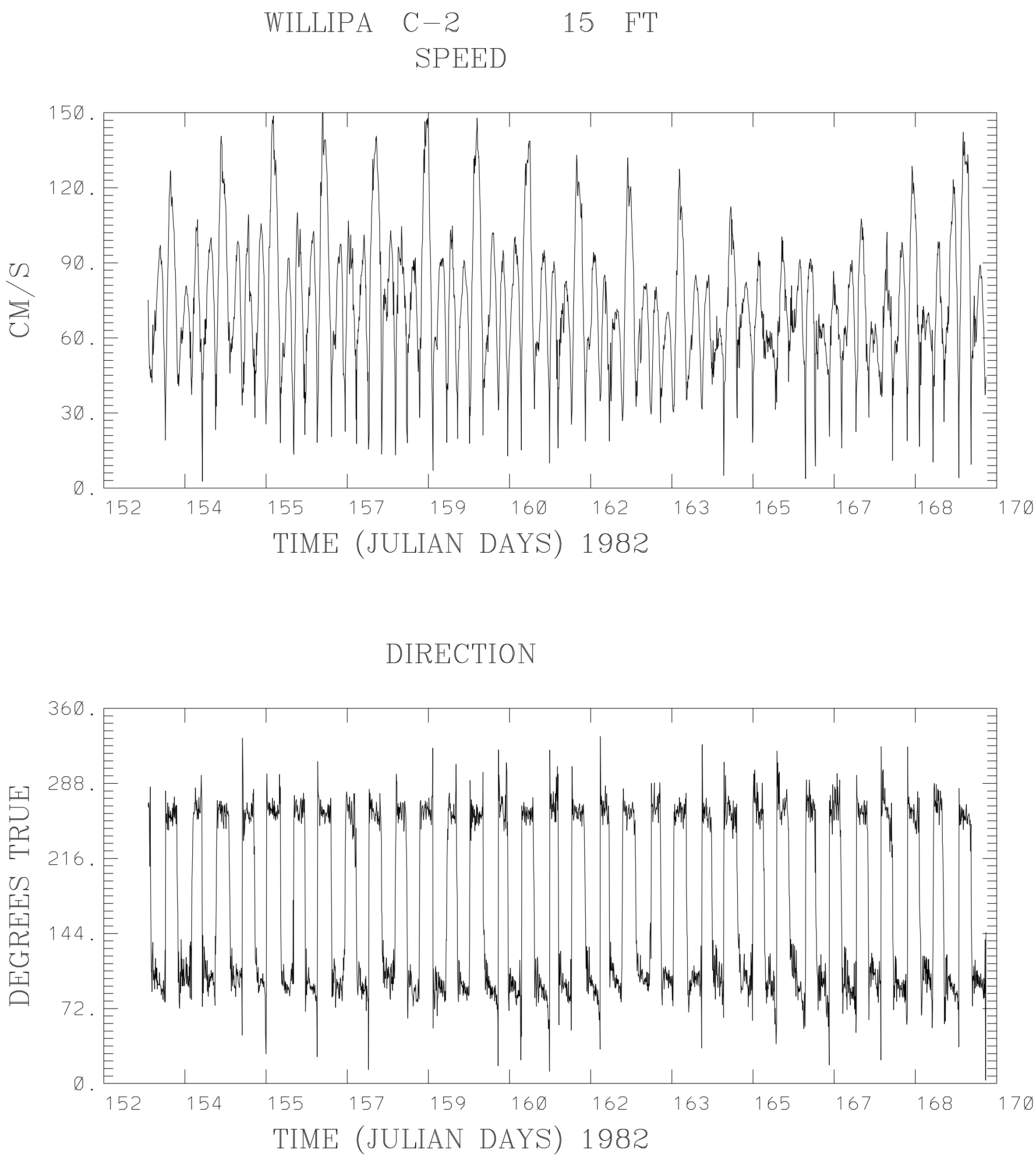


Figure 5.10. Station C-2 Willapa Bay Current Speed and Direction at 15 ft above the bottom in June 1982.

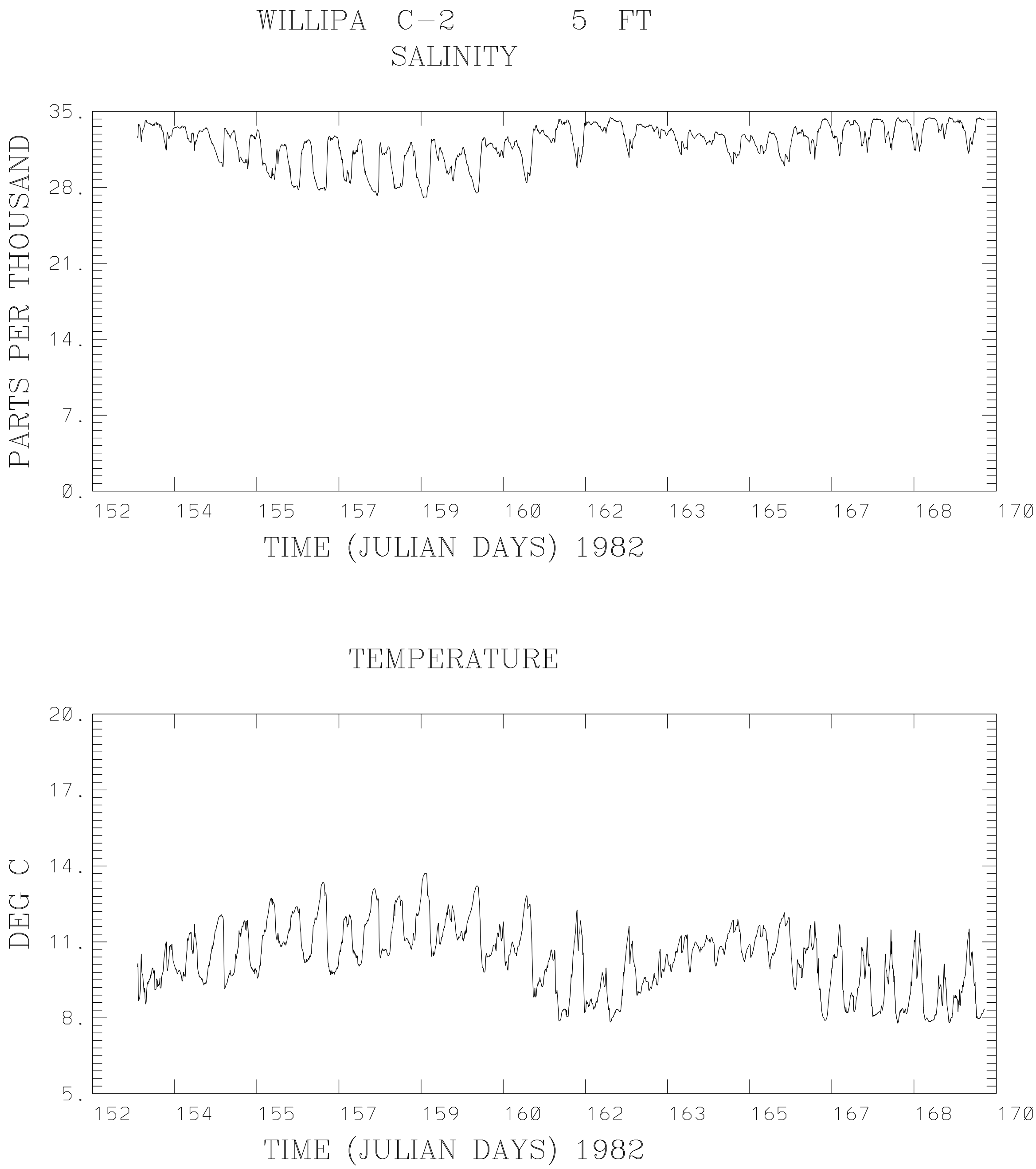


Figure 5.11. Station C-2 Willapa Bay Salinity and Temperature at 5 ft above the bottom in June 1982.

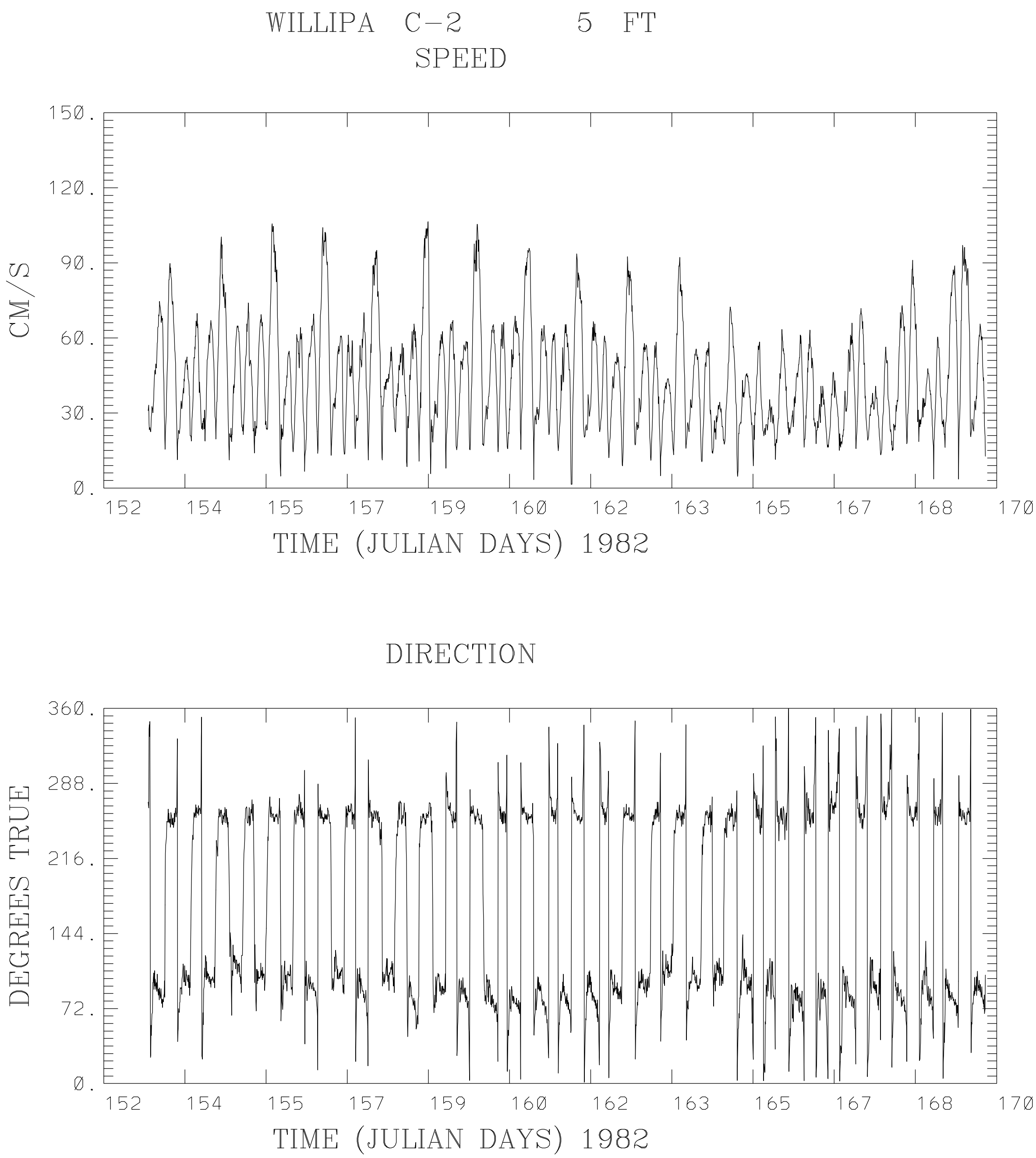


Figure 5.12. Station C-2 Willapa Bay Current Speed and Direction at 5 ft above the bottom in June 1982.

6. COOS BAY

NOS performed a short survey in 1982 to study the circulation in Coos Bay. While no record of this circulation survey is available, it is known that the Aanderaa Model RCM-4 current meter recorded and measured current speed and direction and included temperature, conductivity and pressure sensors. Here, we summarize the recovered data and discuss related regional oceanographic characteristics.

Data Inventory and Summary

The datasets obtained from CO-OPS on compact disc are listed in Table 6.1 and constitute the recoverable data. It was necessary to carefully inventory these datasets and determine their data quality. Note neither meteorological data (wind speed and direction, sea level atmospheric pressure) nor CTD profile data were available.

Table 6.1. Coos Bay Circulation Survey Raw Data Inventory.

Directory Name	Number of Files	Data Period	Data Description	Data Quality
COOS1	13	1982	Aanderaa Current Meter	OK
COOS2	12	1982	Aanderaa Current Meter	OK

CT/Current Data

The salinity, temperature and current data inventoried in Table 6.2 were distributed in two directories: COOS1 and COOS2. These data files (FILE1 through FILEn) were concatenated to create cumulative data files: file_coos1 and file_coos2. The data in each individual data file (FILE1 through FILEn) represent current and CT data at one specific station location over a given time period. It should be noted that since the focus was on data for model validation and harmonic analysis, only stations with record lengths of 15 days or greater were considered. In general, data quality was sufficient such that no filtering or editing was performed.

Table 6.2. Coos Bay Circulation Survey Processed Data File Inventory.

Data Type	Location	Filename
CT/Current Raw	~/coos_bay/COOS1/ ~/coos_bay/COOS2/	FILE1 – FILE13 FILE1 – FILE12
CT/Current Edited	~/coos_bay/coos1/ ~/coos_bay/coos2/	file_coos1 file_coos2
CT/Current Qc	~/qc/	file_coos1.qc file_coos2.qc

~ = /disks/NASUSER/philr/westcoast

Datasets 1 and 2 are described in Table 6.3, in terms of station location, measurement and station depths and measurement dates and durations. Note that in the table the station depths are estimated from Nautical Chart 18587 70th Edition. Station locations are shown in Figure 6.1. Since only 2 out of the 25 current meter deployments contained uninterrupted measurements greater than 15 days, Table 6.3 was expanded to include information on all deployments for this survey. Station C-44 appears to be on land.

Table 6.3. Coos Bay Datasets 1 and 2.

Station No.	Latitude (°N)	Longitude (°W)	M-Depth (ft)	S-Depth (ft)	Measurement Dates mm/dd/yr		Data Length Days	Data Quality STAD
C-37	43.434	124.233	5	19	9/28/82	10/ 5/82	6.35	
C-38	43.429	124.226	5	16	9/28/82	10/ 8/82	10.16	
C-36	43.423	124.252	5	25	9/27/82	10/ 5/82	8.04	
C-30	43.355	124.324	30	39	9/21/82	9/30/82	9.08	
C-32	43.365	124.313	15	18	10/ 1/82	10/ 9/82	7.79	
C-32	43.365	124.313	5	18	9/27/82	10/ 3/82	5.81	
C-40	43.406	124.214	5	20	9/24/82	9/30/82	5.34	
C-39	43.417	124.214	15	25	9/28/82	10/13/82	14.89	
C-41	43.383	124.218	5	36	9/20/82	10/ 3/82	12.58	
C-41	43.383	124.218	5	36	10/ 6/82	10/13/82	6.85	
C-44	43.353	124.192	5	n/a	9/29/82	10/13/82	14.20	
C-42	43.374	124.186	5	10	9/24/82	10/ 8/82	13.76	
C-41	43.383	124.218	5	36	9/ 7/82	9/20/82	12.76	
C-32	43.365	124.313	15	18	9/20/82	9/27/82	6.97	
C-32	43.365	124.313	5	18	9/21/82	9/27/82	6.10	
C-36	43.423	124.252	5	25	9/ 8/82	9/16/82	7.79	
C-38	43.429	124.226	5	16	9/ 8/82	9/14/82	6.12	
C-38	43.429	124.226	5	16	9/20/82	9/28/82	8.00	
C-34	43.399	124.282	15	38	9/24/82	9/28/82	4.69	
C-34	43.399	124.282	5	38	9/23/82	9/28/82	4.82	
C-37	43.434	124.233	5	19	9/20/82	9/28/82	7.93	
C-44	43.353	124.192	5	n/a	9/ 7/82	9/20/82	12.81	
C-39	43.417	124.214	5	25	9/22/82	9/28/82	5.92	
C-41	43.383	124.218	20	41	9/20/82	10/13/82	23.11	
C-39	43.417	124.214	15	30	9/ 7/82	9/28/82	20.94	

Notes: M-Depth=measurement depth with respect to MLLW, where positive numbers are distance above the bottom and negative numbers are distance below the surface. S-Depth=station depth with respect to MLLW. Note x denotes bad data within the STAD station matrix where S=salinity, T=temperature, A=current speed, and D=current direction.

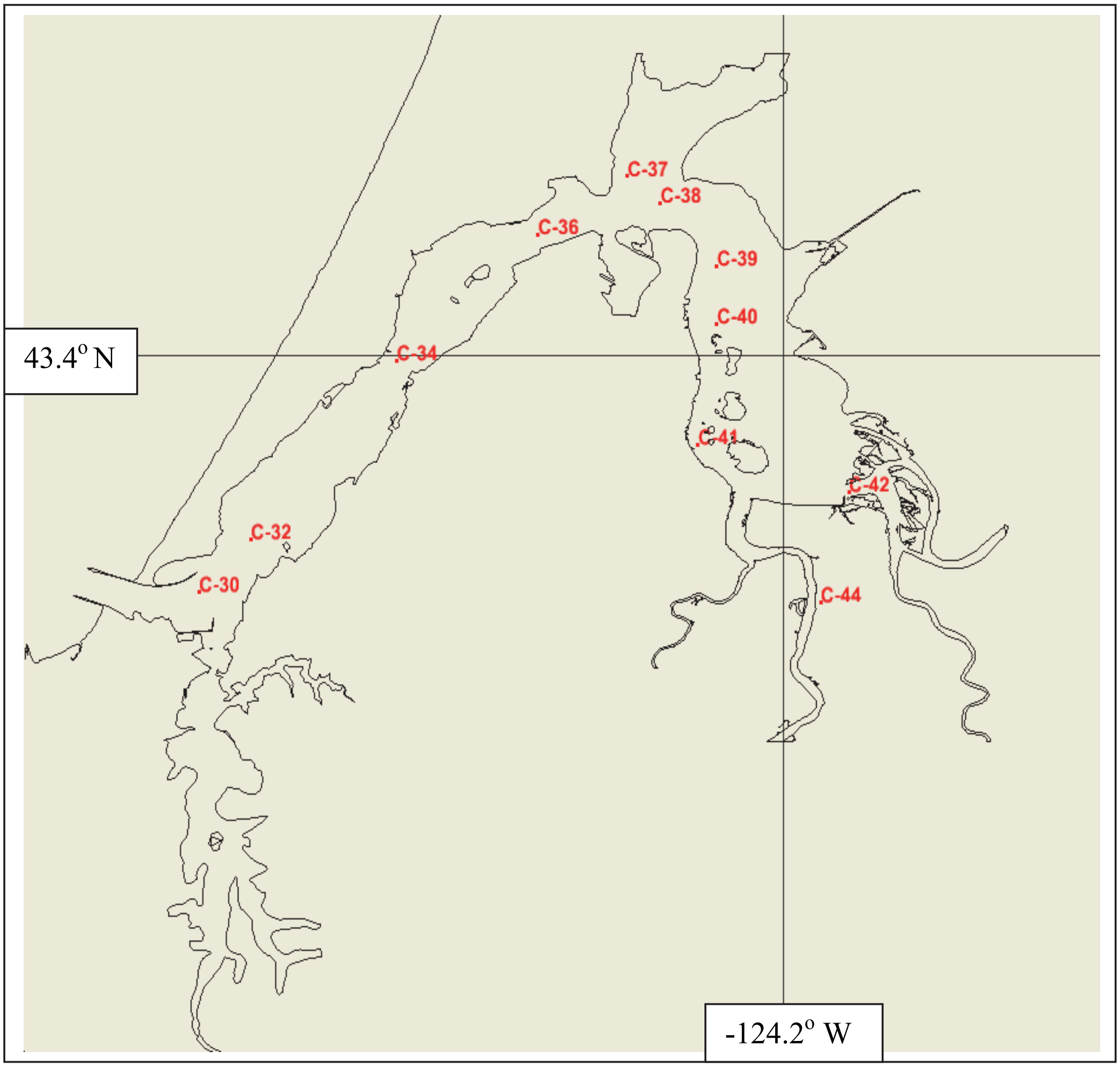


Figure 6.1. Station Locations for Coos Bay Dataset 1.

Regional Oceanographic Characteristics

Garfield et al. (2005) developed a NOAA strategic plan to define a strategy for development of an enhanced coastal observational system for the Coos Bay estuary. Here, we briefly review their description of the estuarine system.

The Coos Bay estuary covers 54 square miles of open channels and periodically inundated tide flats located near the town of the same name on the southern Oregon coast. About half of the estuary is dominated by marine waters that enter on flooding tides. The remaining half is composed of a mixture of mesohaline and riverine waters. A ship channel is maintained from the harbor entrance to the Port of Coos Bay. This ship channel is 42 feet deep and sixteen miles long. At low tide, a substantial portion of the water in the bay is held within the ship channel.

The narrow estuary is maintained at its mouth by two rock jetties extending from North Spit on the north and Coos Head on the south. Improved understanding of the sediment transport mechanisms in this region of the estuary can support strategies to stabilize the spit's shoreline and reduce its vulnerability to erosion. From the harbor entrance, the main channel bears northward, then to the east around the city of North Bend, and south into Coos Bay. At Coos Bay, the channel bears east again and encounters the mouth of the Coos River. About two miles upstream, the river divides into the Millicoma River on the left and the South Fork of the Coos River on the right. The estuary ranges between a mile and a mile and a half wide.

Numerous slough systems and freshwater channels flow into Coos Bay. The South Slough sub-estuary is located directly south of the mouth of Coos Bay. This convergence of the South Slough, greater Coos Bay, and the nearshore waters of the Pacific Ocean present a very complex hydrodynamic regime. North Slough and Haynes Inlet enter the bay from the north. Pony Slough drains northward through the city of North Bend to the bay. Kentuck Inlet, Willanch, Catching, Isthmus, Coalbank, and Shiglehouse sloughs flow into the eastern and southern portions of the bay.

The Coos and Millicoma Rivers above the head of tide contribute approximately 60 percent of the fresh water entering Coos Bay. The other 40 percent is contributed by the slough systems and runoff apparently originating below the heads of tide. Understanding the origin of the 40 percent of ungauged fresh water contribution is critical to understanding the hydrological inflows into Coos Bay.

McAlister and Blanton (1963) describe temperature, salinity, and current measurements in Coos Bay, which could be used as a supplement to those reported here. They note that Coos Bay ranges from a well-mixed during periods of low runoff to a partially-mixed estuary during periods of maximum runoff. They reported that the intensity and scale of turbulence varied with stage of the tide with eddy diameters from as small as could be observed to 500m.

Here we examine the response at Station C-39 15 ft above the bottom during September 1982. Salinity and temperature measured time series are shown in Figure 6.2. Note the irregularity of the salinity response near Julian day 267. Current speed and direction are shown in Figure 6.3, with some noise evident in the current directions.

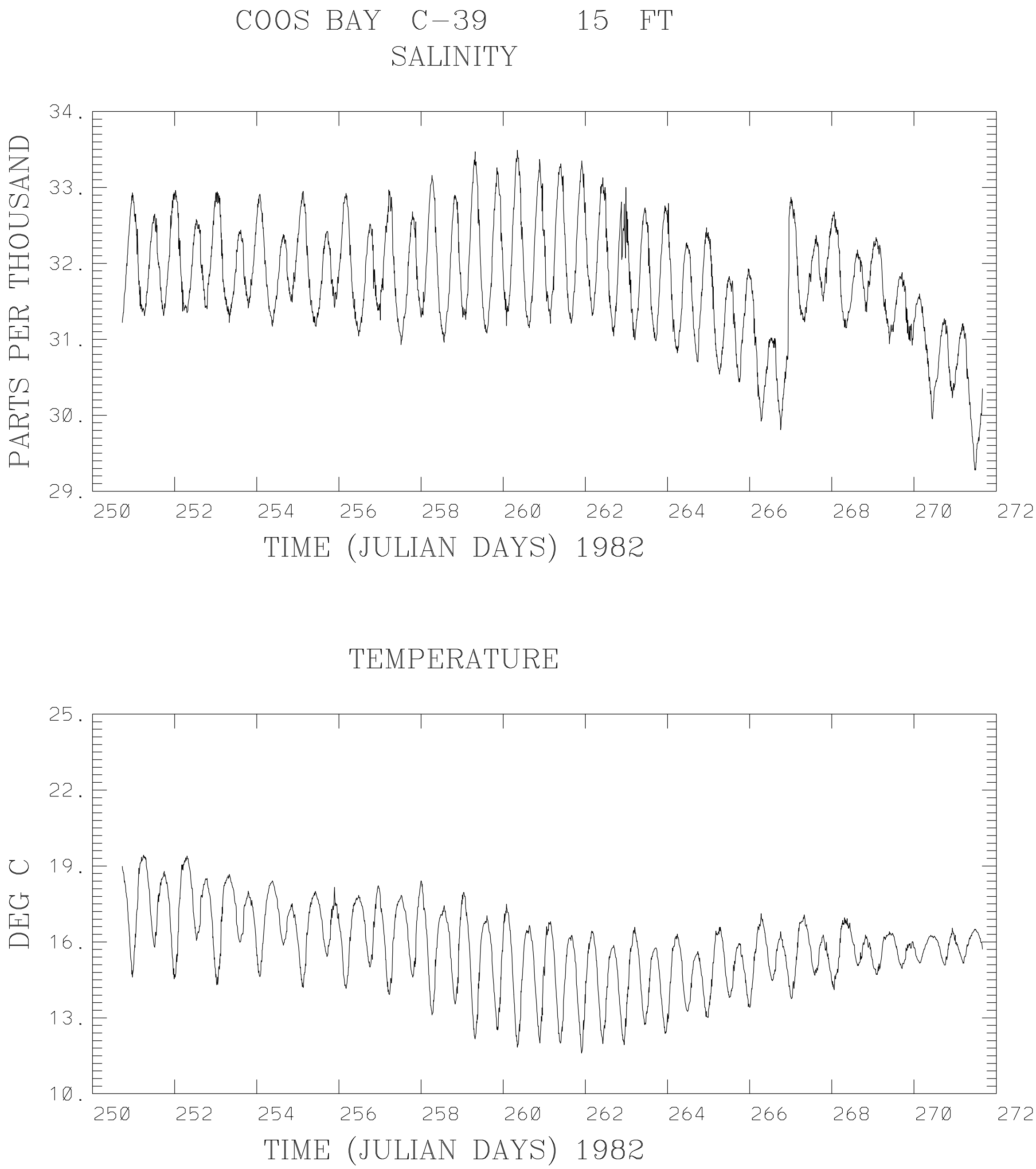


Figure 6.2. Station C-39 Coos Bay Salinity and Temperature at 15 ft above the bottom in September 1982.

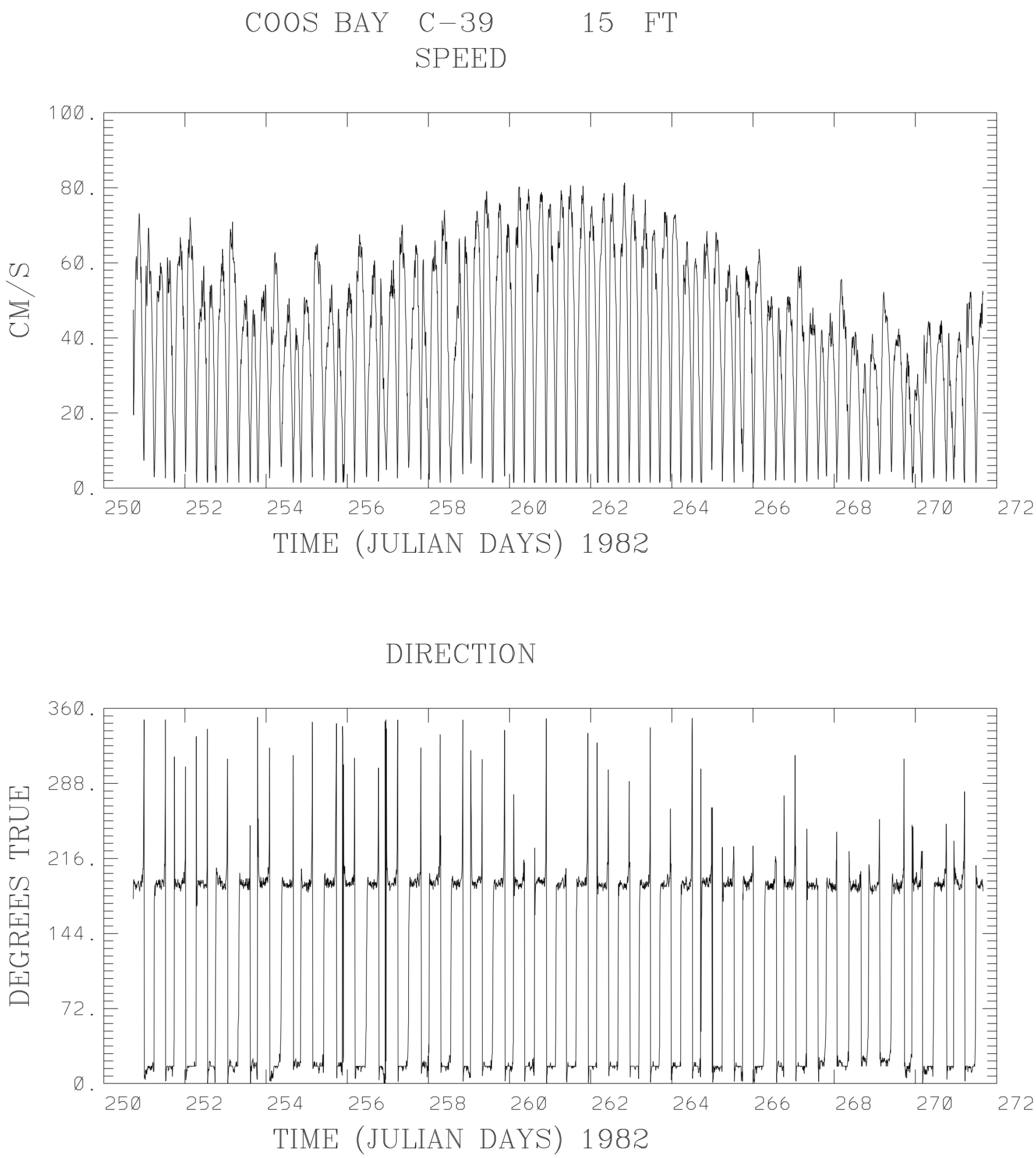


Figure 6.3. Station C-39 Coos Bay Current Speed and Direction at 15 ft above the bottom in September 1982.

7. DATA PRESERVATION AND USE ISSUES

Preservation

An NOS circulation survey report is available for Puget Sound (Parker and Bruce, 1980), while no final project report memoranda are available for Yaquina River, Willapa Bay/Grays Harbor and the Coos Bay survey. Data for each of these circulation surveys were probably submitted to NODC for archiving and preservation. However, NODC archives did not contain the original datasets in uncorrupted format. The data corruption and preservation issues are discussed in CO-OPS (1999), particularly with respect to CTD time stamp corruption. In large measure data were corrupted in migration from storage media associated with each new computer system. To prevent this, data redundancy and backup procedures need to be addressed.

Use

The primary use of these processed circulation survey datasets is anticipated to be in the support of model evaluation environments and in supporting the development of nowcast/forecast systems. This effort focused on the restoration and quality control of these datasets. It should be noted that the final processed data were written in the same format as the original data. No rearrangement of the data file structures was undertaken. No data editing was performed to remove bad portions of data. Therefore additional consistency checking should be performed. Since no station depths are available for the Yaquina River, Willapa Bay/Grays Harbor and Coos Bay circulation surveys and only limited station depths for Puget Sound, station depths were estimated from the appropriate nautical charts.

For current meter data, computer programs developed by Richardson and Schmalz (2006) can be used to determine the principal component directions using the Preisendorfer scheme and to automatically prepare control and input data files for the NOS 15-day and 29-day harmonic analysis programs (Zervas, 1999). NOS 15-day harmonic analysis results for currents in Puget Sound are reported by Parker (1977).

8. SUMMARY AND RECOMMENDATIONS

Three sets of programs have been developed to analyze the circulation survey data. The first program set was not used to plot and edit CTD profiles since no CTD data were available. The second program set was used to analyze the CT/Current meter files. The first program in program set two was used to plot station time series data in Puget Sound, Yaquina River, Willapa Bay/Grays Harbor and Coos Bay. Since this effort focused on the data restoration and inventory of available data, no formal data quality was performed. However, within the present plot program, editing and filtering steps are included and can be exercised in the future as required. All time series greater than 15 days were written for incorporation in the CSDL Oracle database.

The first program in program set two was modified to write out the final quality control station data in NOS skill assessment format as discussed by Zhang et al. (2009) and was used to process the Puget Sound data. The second program in program set two is available to determine the principal current direction using the Preisendorfer scheme and to prepare the control and data files for use in the NOS 29-day harmonic analysis program, which is the first program in program set three. Note minor modification may be required to prepare the inputs for the NOS 15-day harmonic analysis program, which is the second program in program set three. Since harmonic analysis results have been reported by Parker (1977), this program was not used in this study.

In summary, this report has documented the restoration of the NOS historical circulation surveys in Puget Sound, Yaquina River, Willapa Bay/Grays Harbor and Coos Bay. The report serves as a circulation survey report for the Yaquina River, Willapa Bay/Grays Harbor and Coos Bay surveys and complements the Puget Sound survey report by Parker and Bruce (1980). All restored files will be available on CSDL/MMAP servers on /disks/NASUSER until they are transferred to NODC and CO-OPS for data request, redundancy and archival purposes.

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